Proceedings of the

TEACHERS' SEMINAR ON PHARMACEUTICAL CHEMISTRY

July 7-12, 1952

HELD UNDER THE AUSPICES OF THE AMERICAN ASSOCIATION OF COLLEGES OF PHARMACY

at

College of Pharmacy

University of Michigan

Edited by

TOM D. ROWE

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INTRODUCTION

The proceedings of the Teachers' Seminar on Pharmaceutical Chemistry contain the complete report on the papers presented during the week. Space does not permit the inclusion of the discussions which contributed materially to the interest of the program. A copy of the proceedings is being sent to each registrant and two copies to the dean of each of the schools and colleges of pharmacy.

The Seminar was held at the University of Michigan July 7 through 12. As usual, the Seminar was sponsored by the American Association of Colleges of Pharmacy and was financed by funds allotted to the organization from the American Foundation for Pharmaceutical Education. The program was arranged to cover all phases of basic and pharmaceutical chemistry starting with the beginning courses of the freshman year and going on through to graduate work in this field. This was a large undertaking, but fortunately there is available in pharmaceutical chemistry departments and industries throughout the country the personnel to handle the job.

A faculty of 39 members presented papers during the twelve sessions that were held. A total of 179 registered for the Seminar. These were from 64 schools, 4 of which were Canadian colleges of pharmacy. Thirty-six states and the District of Columbia were represented. In addition to the colleges, there were 11 pharmaceutical manufacturers who had representatives either in attendance at the meeting or participating in the program. Eight other companies had equipment on display in the College of Pharmacy laboratory, and books from various publishers were also exhibited.

From the comments made during the week and from letters received later by the Chairman of the Committee it appears that the Seminar was most successful. Those in attendance expressed the general feeling that the program had done a great deal to help improve the teaching in the field of pharmaceutical chemistry.

The Committee feels that the quality of the papers was exceptionally fine and that we can well be proud of the men who are responsible for the teaching in the field of pharmaceutical chemistry. There was spirited and interesting discussion on almost all of the papers.

One thing that was apparent to the Committee, and which we felt was a good thing for the future of pharmacy, was that at least half of those in attendance were teachers of the younger group, in whose hands lie the future of this field and other fields of pharmacy. Not only did they learn of some of the problems which have been and are being faced in pharmacy, but they contributed materially to the success and interest of the various programs.

No remarks concerning this Seminar would be complete without acknowledging the important part played by the Foundation in making these meetings possible. The Foundation has allotted, for previous seminars and for this one too, the sum of $6,000 to underwrite the cost of these sessions. Without these grants, these meetings would not be possible. The Committee congratulates the Foundation for its continuing support of this activity for bettering education in pharmacy. We also wish to thank all of those who participated in the program.

Perhaps the success of the meetings can best be summed up by a paragraph from a letter which was sent to the Chairman by one of the members who attended. He wrote: "The Seminar at Ann Arbor was, in my opinion, one of the most constructive programs which the A.A.C.P. has ever sponsored. I came back from Ann Arbor with a new feeling of enthusiasm, not only for my teaching, but for the future of American pharmacy." If we can assume that this opinion expresses the feeling of most of those who attended, we believe that the Seminar was indeed a success and that it accomplished its objective of helping to improve the quality of teaching in pharmaceutical chemistry.

Respectfully submitted,

A. A. C. P. Committee on Seminar
F. F. Blicke
J. B. Burt
L. M. Parks
J. A. Reese
L. C. Zopf
T. D. Rowe, Chairman

OBJECTIVES OF THE TEACHERS' SEMINAR ON PHARMACEUTICAL CHEMISTRY

Tom D. Rowe

Chairman, Seminar Committee, and Professor of Pharmacy and Dean, College of Pharmacy, University of Michigan

Obviously, the objective of this Seminar is to help improve the quality of teaching in pharmaceutical chemistry. In the Findings and Recommendations of the Pharmaceutical Survey, the recommendation which was partly responsible for the inauguration of these seminars states: "The primary purpose of these Seminars is that of providing needed opportunity for the members of the teaching staffs, and for graduate students to come into fruitful contact and to keep pace with progressive content and methods of pharmaceutical teaching."

When the Seminar Committee met in Ann Arbor last January to plan the program, the purpose stated in the recommendation was kept constantly in mind. In a field as large as pharmaceutical chemistry, the opportunities are great and the temptations even greater to roam into nonteaching pastures. In our discussions we often did this, but we always returned to the central theme of how to help improve the teaching in this area.

It was decided at the outset that, in the week allotted to us, we should try to cover the entire field. To this end, the first day is devoted to setting the background for subsequent sections. After that, we have tried, so far as possible, to go through the pharmacy curriculum starting with beginning chemistry and finishing with courses on the graduate level.

This is a large undertaking, but fortunately there is available, in pharmaceutical chemistry departments and in industries throughout the country, personnel to handle this job. You may recall Dr. Deno's classification of college teachers which he presented in a paper at the Buffalo meeting last year. His classification was: professionals, semiprofessionals, and pinch hitters. The faculty assembled for these sessions is composed entirely of full-fledged professionals.

Even a group as well qualified as this one, however, cannot solve in one week all the problems of our teaching methods nor make our teaching 100 per cent effective. Their presentations and the discussions will present ideas which will make our teaching better than before.

In the papers to be presented both course content and teaching methods will be discussed. Teaching methods have shown less flexibility than course content during the past fifty years. While course content has changed and improved the methods for presentation have remained practically static. This has been true in many other fields besides pharmaceutical chemistry. We hope that during this Seminar new ideas on improved teaching methods will be forthcoming.

We are pleased that the University of Michigan was selected by the Executive Committee of the A.A.C.P. to be the host for this meeting. To those of us connected with pharmacy at Michigan, it seems fitting that this first seminar in pharmaceutical chemistry should be held at the institution in which this subject as we know it today was first offered. We are also pleased to have you here, because this meeting makes a most fitting conclusion to our Seventy-fifth Anniversary year.

No remarks concerning the Seminar would be complete without acknowledging the important part played by the A.F.P.E. in making these meetings possible. As you know, the Foundation has allotted in past years, and for this one too, the sum of $6,000 to underwrite the costs of these sessions. Without its grant, these meetings would not be possible. I am sure I speak for all of us when I extend our thanks to the Foundation for its generosity and interest in bettering education in pharmacy.

On behalf of the A.A.C.P., the A.F.P.E., and the University of Michigan, I extend you a most cordial welcome. We hope your stay in Ann Arbor will be personally enjoyable and professionally profitable.

TEACHING PATTERNS IN PHARMACEUTICAL CHEMISTRY

Richard A. Deno

Director of Educational Relations,
American Council on Pharmaceutical Education

The Chairman of the Seminar has stated that this paper should give a description of the undergraduate courses in pharmaceutical chemistry as now offered in the seventy-four accredited American colleges of pharmacy, including content, sequence, time allotments, et cetera. He has also indicated that it would be proper briefly to include comments on such matters as common weaknesses and relationships to other basic and professional scientific courses.

Definition of pharmaceutical chemistry. Since I am not a chemist, a precise definition of pharmaceutical chemistry would be especially useful to have at the outset -- a definition which would be acceptable to all chemists teaching in colleges of pharmacy and which would clearly delimit the area of pharmaceutical chemistry. As far as I know, no one has provided such a definition, and it is quite possible that no universally acceptable one can be phrased.

Three general concepts of the meaning and scope of pharmaceutical chemistry exist in the colleges. In the broad sense, pharmaceutical chemistry is taken to include all chemistry courses taught to pharmacy students, beginning with general chemistry. This concept is held today by only a few pharmacy faculties; it was much more common a generation or so ago.

Of the seventy-four accredited colleges, 19 (26%) of them teach all of the chemistry courses in the college of pharmacy proper. These colleges are usually independent ones or are geographically isolated from other units of a parent institution. One or two of them have charge of all chemistry on a small campus, and the basic courses are open to nonpharmacy students. One or two others are integral parts of a university, both in administration and in location, but they do not choose to utilize the chemistry departments of the universities. In most of these colleges the distinction between courses in basic chemistry and courses in applied phases is clearly recognized and readily acknowledged. In a few cases the teaching personnel insists that all chemistry courses are pharmaceutical chemistry "because pharmaceutical examples are used throughout the courses."

In the restricted sense, pharmaceutical chemistry is taken to mean only those chemistry courses which deal with strictly pharmaceutical applications of chemistry. A common undergraduate pattern here is to include under pharmaceutical chemistry only inorganic pharmaceutical chemistry, organic pharmaceutical chemistry (the chemistry of organic medicinal products), and drug assay. Courses ordinarily found in a university chemistry department are classed as basic courses and are taught by nonpharmaceutical personnel. There are twenty-seven (36%) accredited colleges of pharmacy where this pattern prevails.

An intermediate condition exists in twenty-eight (38%) of our accredited colleges of pharmacy. In these colleges all of the applied courses as well as some of the basic courses are taught by personnel of the colleges of pharmacy. In every case of this sort general chemistry is taught in a chemistry department, and usually qualitative analysis is also taught there. Quantitative analysis, organic chemistry, biochemistry, or two or three of these courses are given by pharmacy college personnel.

Obviously, these three patterns are about equally common. Slightly less than one-third of the colleges have all chemistry courses in the colleges of pharmacy. A little more than one-third of the colleges depend upon university chemistry departments for all of their basic courses. And a little more than one-third of the colleges receive service from university chemistry departments for part of the basic work and give some of the courses in basic chemistry in the colleges of pharmacy. As far as I know, all strictly pharmaceutical chemistry required of undergraduates in pharmacy is taught by teachers on the staffs of the colleges of pharmacy. The teachers may or may not be trained in pharmacy.

Courses required in seventy-four accredited colleges of pharmacy. Tabulation of the number of colleges requiring various courses in basic and pharmaceutical chemistry is given in Table I. The scope of some of the courses will be discussed later. From Table I it can be seen that every college includes instruction in general chemistry, qualitative analysis, quantitative analysis, and organic chemistry. These courses are ordinarily considered to be basic ones. In two-thirds of the colleges qualitative analysis is combined with general chemistry. In thirteen colleges a combination is effected between basic quantitative analysis and drug assay.

Two other basic courses are given in certain colleges. Physical chemistry is included in four curriculums, and biochemistry in forty-nine institutions (two-thirds of the accredited colleges). One year ago biochemistry was required in only thirty-five colleges; twenty-nine of these included laboratory

TABLE I

Chemistry Courses in 74 Accredited Colleges of Pharmacy

(Figures indicate number of colleges)

Course	Didactic and Lab. Instruction	Didactic Instruction Alone	Not Required
Gen., incl. Qual.	49	0	
Gen.	25	0	0
Qual.	26	0	
Quant.	61	0	
Quant., incl. Drug assay	13	0	0
Drug assay	45	0	29
Organic	74	0	0
Physical	3	1	70
Biochem.	42	7	25
Inorg. ph. ch.*	27	29	
Inorg. and Org. ph. ch.	1	3	14
Org. ph. ch.**	28	40	2

* In 21 of the colleges included here, the course is called inorganic pharmacy.

** In 19 of the colleges included here, the course is called organic pharmacy.

instruction and six colleges give didactic instruction only (1). In 1946, Dr. H. B. Lewis expressed the opinion that the status of biochemistry in pharmacy colleges was essentially as in 1939 (2). In 1939 a Subcommittee of the Syllabus Committee found biochemistry required in only eighteen colleges. Also in 1939 Dr. Lewis stated "that the inclusion of biochemistry as a required subject (in the Pharmaceutical Syllabus) would be necessary within ten years unless the trends in professional pharmacy and in medicine changed materially". The Syllabus has been abandoned, but today, three years after expiration of the ten-year estimate, biochemistry is required in two-thirds of our colleges. If Dr. Lewis will give us another five years, I believe it will be in every curriculum.

Some instruction in inorganic pharmaceutical chemistry unquestionably is given in every college. Fourteen colleges, however, do not have courses designated either inorganic pharmaceutical chemistry or inorganic pharmacy. They include instruction in inorganic pharmaceutical chemistry in general pharmacy or in some other pharmacy course. In twenty-one colleges the course in inorganic pharmaceutical chemistry is termed inorganic pharmacy. In four colleges inorganic and organic pharmaceutical chemistry are offered as a combined course. The remaining thirty-five colleges have separate courses designated inorganic pharmaceutical chemistry or an equivalent phrase which includes reference to chemistry.

Likewise instruction in organic pharmaceutical chemistry is given in every college. In two instances it is included in general pharmacy. In nineteen colleges the course is termed organic pharmacy. In four colleges organic and inorganic pharmaceutical chemistry are offered as a combined course. The remaining forty-nine colleges have one or more courses designated organic pharmaceutical chemistry or an equivalent phrase which includes reference to chemistry.

Drug assay, or an equivalent designation, is required in forty-five colleges as a separate course and in thirteen other colleges, combined with basic quantitative analysis. There are thus twenty-nine colleges which do not require a separate course in drug assay, and sixteen which require no work at all in this subject and usually offer instead elective courses in drug assay.

Elective courses in chemistry have not been tabulated because the colleges vary greatly with respect to them. In large universities pharmacy students usually may elect any chemistry course for which they have the prerequisites and the time. In smaller institutions a few electives are frequently available. In most instances, however, the curriculum does not permit the regular pharmacy student to elect even one additional course in chemistry.

Sequence of courses. In Table II are shown the years in which the various courses are required in the seventy-four accredited colleges of pharmacy. For the most part, the sequence is logical as far as

TABLE II

Years in Which Chemistry Courses Are Given in 74 Accredited Colleges of Pharmacy

(Figures indicate number of colleges)

Course	Prepharmacy or freshman	Sophomore	Junior	Senior
Gen., incl. Qual.	49			
Gen.	24	1		
Qual.	1	20	5	
Quant.	2	32	27	
Quant., incl. Drug assay			10	3
Organic	4	61	9	
Physical			4	
Biochem.		3	21	25
Inorg. ph. ch.		20	32	4
Org. ph. ch.			39	27
Inorg. and org. ph. ch.			2	2
Drug assay		1	20	24

the chemistry courses themselves are concerned, but it is not entirely logical in relation to certain other courses. Some of these relations will be considered later.

Most of the colleges (88%) now give organic chemistry before the junior year rather than in the junior year as formerly. This is undoubtedly due to the demands for knowledge of organic chemistry in a number of biology and pharmacy courses ordinarily given before the senior year. Combination of qualitative analysis with general chemistry obviously facilitates presentation of organic chemistry before the junior year.

Time factors for required courses. Clock hours for the various chemistry courses are shown in Table III. Clock hours are given because they are more informative than credit hours. (Nineteen of the seventy-four accredited colleges operate on the quarter system. Several colleges give one hour credit for two hours per week of laboratory work. Other colleges require three, four, or more than four hours of laboratory work per week per credit hour, especially in analytical and in organic chemistry.)

General chemistry, including qualitative analysis (combined course, forty-nine colleges). The modes and the medians for this course represent 3 hours of didactic instruction and 6 hours laboratory work per week throughout a year, for 10 semester hours of credit. Position of the course is invariably in the freshman or prepharmacy years. Usually, about one-third of the course is devoted to qualitative analysis. Semimicro procedures are frequently followed in the laboratory.

General chemistry (twenty-five colleges). The modes and the medians for this course represent 3 hours of didactic instruction and 3 hours of laboratory work per week throughout a year, for 8 semester hours of credit. Position of the course is in the freshman or prepharmacy years for all colleges except one.

Qualitative analysis (twenty-six colleges). The modes and the medians for this course represent 2 hours of didactic instruction and 6 hours of laboratory work per week for a semester, for 4 semester hours of credit. The usual position of the course is in the sophomore year. Because one college offers a separate course in qualitative analysis in addition to a combined course in general chemistry and qualitative analysis, one more college is indicated here than is indicated under general chemistry.

General chemistry plus qualitative analysis (separate courses, twenty-five colleges). The modes and the medians for the two separate courses added together represent 4 hours of didactic instruction and 6 hours of laboratory work per week throughout a year, for 12 semester hours of credit. In general, then, separate courses devote one hour more per week throughout a year to didactic instruction than do the combined courses. Total laboratory time is essentially the same whether the courses are combined or separate.

Quantitative analysis (basic course, sixty-one colleges). The modes and the medians for this course represent 2 hours of didactic instruction and 6 hours of laboratory work per week for one semester, for 4 semester hours of credit. The position of the course is about equally divided between the sophomore and the junior year. A few more colleges favor the sophomore rather than the junior year. In forty-five of the sixty-one colleges, an additional course in quantitative pharmaceutical chemistry (drug assay) is required.

TABLE III

Clock Hours for Chemistry Courses Required in Accredited Colleges of Pharmacy

(Parenthetical figures indicate number of colleges)

Course	Instruction	Mean	Median	Mode	Range
Gen., incl. qual. (49)	lect.	101	96	96(21)	64-154
	lab.	163	192	192(18)	96-288
	total	264	272	288(13)	192-384
Gen. (25)	lect.	96	96	96(16)	64-128
	lab.	110	96	96(11)	64-192
	total	206	192	102(8)	132-288
Qual. (26)	lect.	37	32	32(13)	16-64
	lab.	84	96	96(15)	48-128
	total	121	128	128(11)	80-176
Gen. and qual. (25)	lect.	133	128	128(9)	88-176
	lab.	194	192	192(7)	128-288
	total	327	336	336(3)	220-416
Quant. (61)	lect.	36	32	32(34)	16-80
	lab.	98	96	96(31)	48-192
	total	134	128	128(24)	88-256
Quant., incl. Drug assay (13)	lect.	65	64	64(5)	44-99
	lab.	141	132	132(5)	88-198
	total	206	198	198(4)	132-297
Drug assay (45)	lect.	32	32	32(22)	11-96
	lab.	85	96	96(14)	44-192
	total	117	112	128(8)	32-224
Quant. and drug assay (45)	lect.	66	64	64(18)	32-128
	lab.	183	192	192(14)	110-288
	total	248	256	256(7)	176-352
Organic (74)	lect.	89	96	96(37)	44-132
	lab.	132	128	96(25)	64-198
	total	221	220	192(20)	112-297
Physical (4)	lect.	43	--	--	32-64
	lab.	49	--	--	0-96
	total	92	--	--	64-128
Biochem. (49)	lect.	54	48	48(14)	16-96
	lab.	65	64	96(15)	0-144
	total	119	121	96(10)	16-198
Inorg. ph. ch. (56)	lect.	44	48	48(26)	22-96
	lab.	30	0	0(29)	0-132
	total	74	64	48(17)	32-176
Org.ph.ch. (68)	lect.	77	80	48 & 96(14ea)	32-176
	lab.	37	0	0(39)	0-192
	total	114	96	96(14)	33-320
Inorg. and org.ph.ch. (4)	lect.	96	96	96(4)	96-96
	lab.	32	0	0(3)	0-128
	total	128	96	96(3)	96-224
All chem. courses (74)	lect.	408	400	368 & 448(6ea)	272-592
	lab.	569	576	576(11)	336-800
	total	977	976	912 & 1088(5ea)	576-1296

Quantitative analysis, including drug assay (combined course, thirteen colleges). The modes and the medians for this course represent 2 hours of didactic instruction and 4 hours of laboratory work per week throughout a year, for 6 semester hours of credit. Most of the thirteen colleges give this course in the junior year. Naturally, emphasis on drug assay usually comes toward the end of the course.

Drug assay (forty-five colleges). The modes and the medians for this course represent 2 hours of didactic instruction and 6 hours of laboratory work per week for one semester, for 4 semester hours of credit. The position of the course is about equally divided between the junior and the senior year. A few more colleges favor the senior rather than the junior year.

Quantitative analysis plus drug assay (separate courses, forty-five colleges). The modes and the medians for the two separate courses added together represent 2 hours of didactic instruction and 6 hours of laboratory work per week throughout a year, for 8 semester hours of credit. In general, then, separate courses devote 2 hours more per week throughout a year to laboratory work than do the combined courses. Total didactic instruction is essentially the same whether the courses are combined or separate.

Organic chemistry (seventy-four colleges). The modes and the medians for this course represent 3 hours of didactic instruction and 3 or 4 hours of laboratory work per week throughout a year, for 8 semester hours of credit. A large majority (88%) of the colleges now give the course earlier than the junior year.

Physical chemistry (four colleges). One of the 4 colleges requiring physical chemistry has a five-year program; the other 3 colleges have four-year programs. Laboratory work is required in 3 of the colleges. The position of the course is in the junior year.

Biochemistry (forty-nine colleges). The modes and the medians for this course represent 3 hours of didactic instruction and 4 or 6 hours of laboratory work per week for one semester, for 4 or 5 semester hours of credit. The position of the course is about equally divided between the junior and the senior year. A few more colleges favor the senior rather than the junior year.

Inorganic pharmaceutical chemistry (fifty-six colleges). The modes and the medians for this course represent 3 hours of didactic instruction per week and no laboratory work for one semester, for 3 semester hours of credit. The position of the course is in the junior year in a majority of the colleges, with a sizable minority giving the course in the sophomore year.

Organic pharmaceutical chemistry (sixty colleges) There is less uniformity in nomenclature, clock hours of didactic instruction, clock hours of laboratory work, and semester hours of credit for this course than for any other chemistry course in the pharmacy curriculum. We will also note later that this course varies more in content and in classification of subject matter than does any other chemistry course in the pharmacy curriculum. More colleges offer 3 hours of didactic instruction per week and no laboratory work throughout a year, for 6 semester hours of credit, than does any other single pattern. The position of the course is in the junior year in a majority of the colleges, with a sizable minority giving the course in the senior year.

Inorganic and organic pharmaceutical chemistry (combined course, four colleges). In three of the four colleges which offer a combined course, 3 hours of didactic instruction per week and no laboratory work are given throughout a year, for 6 semester hours credit.

All courses in chemistry (basic plus pharmaceutical, seventy-four colleges). The last item in Table III shows total clock hours devoted to all required courses in chemistry. The modes and the medians for these courses represent 3 hours of didactic instruction and 4 or 5 hours of laboratory work per week throughout 4 years, for approximately 36 semester hours of credit. Required courses in chemistry account for about 30 per cent of the total clock hours in the four-year curriculum and for about 26 per cent of the total credit hours. To a nonchemist this would appear to be about a maximum.

From the various data on time factors, a composite portrait of required courses in chemistry has been drawn. This portrait is shown in Table IV. It is quite likely that no college requires the courses precisely as indicated. Many colleges, however, closely approximate the situation shown in Table IV.

Nature of required courses. Basic courses found in all curriculums (general chemistry, qualitative analysis, quantitative analysis, organic chemistry) are fairly well standardized in scope and in subject matter. In my opinion, these courses in most of the colleges of pharmacy are reasonably satisfactory modernized versions of traditional courses in basic chemistry.

This statement is not so generally true for biochemistry. You will recall that forty-nine colleges require biochemistry for graduation. The course in half or more of these forty-nine colleges is about as substantial as can be expected from a respectable one-semester course. The traditional scope and subject matter of medical biochemistry are covered fairly well.

In a half dozen or more colleges biochemistry is merely a token course. In perhaps fifteen or twenty other colleges the course is substandard, due either to lack of time allotted to it or to failure to realize the purposes of including biochemistry in a modern pharmacy curriculum. Not infrequently, undue emphasis is placed on clinical biochemistry, at an elementary level. Little or no attention is given to the chemistry of carbohydrates, lipids, and proteins; or to the chemistry of digestion, respiration, and excretion; or to intermediary metabolism. In certain cases some of the omissions are logical because the

TABLE IV

Composite Portrait of Required Courses in Chemistry

(Parenthetical figures indicate semester hours of credit)

Course	Instruction	Clock Hours	Course	Instruction	Clock Hours
Gen. incl.	lect.	96	Inorg.	lect.	48
qual.	lab.	192	ph. ch.	lab.	0
	total	288(10)		total	48(3)
	lect.	32		lect.	96
Quant.	lab.	96	Org.ph.ch.	lab.	0
	total	128(4)		total	96(6)
	lect.	96		lect.	32
Organic	lab.	96	Drug	lab.	96
	total	192(8)	assay	total	128(4)
	lect.	48	All	lect.	448
Biochem.	lab.	64	chem.	lab.	544
	total	112(4)	courses	total	992(39)

subject matter is covered in such a course as the chemistry of natural products.

Courses in inorganic pharmaceutical chemistry vary considerably among the colleges which require them. I have the impression that not infrequently there is needless repetition of subject matter already adequately covered in basic courses in inorganic chemistry. Several teachers of inorganic pharmaceutical chemistry have said that they consider this course to be an essential supplement to pharmacology; that treatment of inorganic medicinal agents is notoriously scanty in most courses in pharmacology; and that the course in inorganic pharmaceutical chemistry is the logical place to remedy this deficiency. The recent revision of the most widely used textbook in this field would seem to support this view. A critical objection to this philosophy is that students are usually not well prepared for pharmacologic instruction at the time inorganic pharmaceutical chemistry is given. Also, teachers of this subject are usually not well trained themselves in pharmacology. If the pharmacologic deficiency in inorganic medicinal products is widespread, then it would seem to be more logical to increase the scope of pharmacology in order to cover inorganic medicinal products adequately.

Courses in organic pharmaceutical chemistry undoubtedly vary more than do courses in any other chemical subject of the pharmacy curriculum. Designations of the courses include organic pharmaceutical chemistry, chemistry of organic medicinal products, and chemistry of organic medicinals. (Some authorities in organic pharmaceutical chemistry object to the use of "medicinal" as a noun, but such usage is fairly widespread among pharmaceutical chemists and is included in Webster). Sometimes the course is divided into one semester devoted to natural products and a second semester to synthetic products. As has been noted, the course is frequently designated pharmacy or pharmacy and chemistry rather than chemistry. A number of colleges have specialized courses in organic pharmaceutical chemistry devoted to individual classes of organic medicinal products, such as vitamins, hormones, and chemotherapeutic agents; or to combinations of such individual classes. Still other designations are sometimes used, but less frequently.

Subject matter of the courses in organic pharmaceutical chemistry is also variable among the colleges. Often the courses are technical chemistry courses with little reference to the pharmacy or pharmacology of the products discussed. Other courses are only partly chemistry, sometimes relatively little chemistry, and could be described more aptly as the materia medica and pharmacy of organic medicinal products.

Classification of the subject matter of courses in organic pharmaceutical chemistry seems to be a knotty problem. Should classification be chemical, therapeutic, or a combination of the two? Should emphasis be placed on the natural in contrast to the synthetic? Perhaps this Seminar will produce some unanimity of judgment on this topic.

I am not entitled to an opinion on the matter of classification, but from talking with teachers of organic pharmaceutical chemistry I have gained the impression that many instructors believe the therapeutic classification is as satisfactory for teaching purposes as is the strictly chemical one, and that the therapeutic classification is more meaningful to students in pharmacy and more useful to practicing pharmacists. Some teachers have said that a strictly chemical classification is confusing to the student and impractical in many respects for the practicing

pharmacist. I know, however, that some organic pharmaceutical chemists hold to as strict a chemical classification as is possible.

Courses in drug assay usually cover chemical procedures found in the assays for drugs and preparations of the United States Pharmacopeia and the National Formulary. In a few courses also included are such nonquantitative procedures as tests for identity and purity. Most of the courses in drug assay appear to be substantial courses in pharmaceutical quantitative analysis.

Teaching personnel and quality of instruction. A year ago in a paper which included discussion of personnel needs in our colleges of pharmacy (3), a rough classification of teachers was proposed: professionals, semiprofessionals, and pinch hitters. For pharmaceutical chemistry the estimate of professionals or satisfactory semiprofessionals teaching in the colleges of pharmacy was forty-nine in seventy-two colleges (68%). A current reconsideration of the qualifications of chemistry teachers in the seventy-four accredited colleges today forces a revision upward. There appear to be fifty-nine colleges (80%) in which the chemistry teachers qualify either as professionals or as reasonably satisfactory semiprofessionals. The revision upward is due, in part at least, to several newly qualified additions during the past year.

Regardless of the accuracy of this estimate of the professional status of chemistry teachers, I am sure that more well-trained instructors are teaching basic and pharmaceutical chemistry to pharmacy students than are teaching any of the other basic sciences, or are teaching in any one of the four other areas of professional instruction (pharmacognosy, pharmacology, pharmacy, or pharmacy administration). I believe pharmaceutical chemistry is better off personnelwise than is any other single area of professional pharmaceutical instruction.

If the preceding statement is true, then it should follow that quality of instruction in chemistry courses is superior to that found in other courses in the pharmacy curriculum. I do not know whether this is true or not. Quality of instruction is difficult to judge. The Accreditation Manual of the American Council on Pharmaceutical Education (4) contains a brief paragraph on effectiveness of instruction, but I know of no study on pharmaceutical chemistry that would be helpful in applying the criteria suggested in the Manual.

Certainly more research is done in pharmaceutical chemistry in colleges of pharmacy than in any other single professional area. This fact might be used to support the argument that teaching in this area is effective in general, but I am not sure that everyone would agree with this thesis. I know that some very effective teaching is done in pharmaceutical chemistry, as well as some slipshod presentation, just as for other subjects in the pharmacy curriculum.

Before leaving the matter of quality of instruction, one feature of instruction in chemistry, as in sciences in general, seems to me worthy of serious thought by this group. In pharmacy colleges we devote nearly one-half again as much time to laboratory work in chemistry courses in toto as to didactic instruction in these courses. Is this rather large proportion of time, nearly one-fifth of the student's total hours in college, spent profitably in the chemistry laboratory? Are the exercises devised so as to teach new techniques, to develop proficiency in important operations, to illustrate a principle, or to show something that can best be presented in the laboratory? Or is time taken for repetitive procedures and mere busy work? I am not making sweeping generalizations. Merely suggesting that any of us teaching laboratory courses would do well honestly to take stock of the needs fulfilled by the laboratory work demanded.

Relationships to scientific courses not chemistry. Basic courses in chemistry help to prepare pharmacy students for the specialized courses in pharmaceutical chemistry. They also give a background essential for courses in general biology, physiology, bacteriology, pharmacognosy, pharmacology, and almost all the courses in pharmacy. Inorganic pharmaceutical chemistry and organic pharmaceutical chemistry both contribute to dispensing pharmacy and to pharmacology. These various relationships cannot be disputed. Yet in many curriculums, a course which should be prerequisite follows a course which needs the basic material.

In a four-year program, or even in a five-year one, the most desirable relationships are not always possible. For a majority of the basic courses, however, it is possible to have them precede the dependent applied courses, and where this is not possible the related courses can be given simultaneously. If physics or biochemistry is to be given in the second semester of the senior year, it might almost as well be omitted.

An especially common example of poor position in the curriculum is biochemistry. This basic course is especially helpful to physiology, bacteriology, pharmacognosy, and pharmacology. Physiology and biochemistry can profitably be given at the same time, and a detailed understanding should be had between the teachers concerning the treatment of topics of common interest. Bacteriology should follow biochemistry in order that discussions of microbial biochemistry and physiology can be presented adequately.

The phytochemical and physiological trend recently taken by pharmacognosy in many colleges calls for a background in biochemistry. Yet very few colleges give biochemistry before pharmacognosy. Instead, much of the general chemistry of carbohydrates, lipids, proteins, and enzymes is given in pharmacognosy, sometimes even before the students have had much organic chemistry. Then these topics are covered again in biochemistry.

The dependency of pharmacology on biochemistry

is becoming increasingly obvious. There is utterly no logic in having pharmacology precede biochemistry. It does this in nine colleges. In a majority of the forty additional colleges which require biochemistry, the two courses parallel one another.

I have acknowledged that desirable relationships among all courses is difficult to bring about in a four-year program. For the courses just cited, however, a reasonably satisfactory solution is possible. With organic chemistry in the sophomore year, biochemistry can be given during the first semester of the junior year, provided quantitative analysis can be squeezed into the sophomore year. This can be done without too much hardship on the student if qualitative analysis is combined with general chemistry in the freshman year, and if the bulk of organic chemistry is given during the first part of the sophomore year.

Physiology can then be given at the same time as biochemistry, during the first semester of the junior year. Bacteriology can immediately follow biochemistry, and pharmacology can be given in logical sequence during the senior year.

The arrangement suggested is simply a realistic solution in which basic courses precede the applied ones. Two ideas quite prevalent in the colleges work against this logical precedence by basic courses. One idea holds that "pharmacy students go to pharmacy college to study pharmacy." Therefore, they must have a good dose of pharmacy the first year and a bigger dose as sophomores. If a third of the freshman courses are applied courses and half of the sophomore ones are in professional areas, then these courses are either substandard ones given without adequate preparation of the student, or much time is consumed in the applied courses in piecemeal presentation of basic concepts.

A second idea that works against logical sequential relationships holds that all scientific courses, especially organic pharmaceutical chemistry and pharmacology, must precede dispensing pharmacy. This philosophy results in crowding all scientific courses other than dispensing pharmacy into the first three years. It is difficult, even in a six-year curriculum, to comply with the requirement of all scientific courses preceding dispensing pharmacy.

A third deterrent to achieving the logical relationships to biochemistry has been the position of organic chemistry in the junior year. Happily, this position has been changed in most of the colleges. The chemists deserve a vote of thanks from the biologists and the pharmacists for co-operating in this change. I find it difficult to understand why more of the biologists do not get busy and rearrange their own courses in order to get the logical sequential relationships now possible.

Many of us hope to see soon at least a five-year program in all of our colleges of pharmacy. Some relief to the vexing problems of sequence will come with a five-year program. In colleges which adopt a 2-3 program and where organic chemistry is not a prepharmacy requirement, however, the same general problem will remain with respect to biochemistry and courses closely related to it.

Another type of problem on relationship of courses is illustrated by biochemistry, the phytochemical-physiological course in pharmacognosy, and certain courses in organic pharmaceutical chemistry (especially those on the chemistry of natural products). We have colleges of pharmacy in which the three courses are given exactly as indicated here.

In the first part of a standard course in biochemistry are covered in some detail the organic foodstuffs: carbohydrates, lipids, and proteins. This coverage usually includes the general chemistry, classification, distribution, biological significance, et cetera. In the newer pharmacognosy we find much of this material repeated, with additional attention to biosynthesis and to plant principles related to the organic foodstuffs. Then, in the course on natural products again come the same plant constituents, with greater emphasis on chemical rather than on biological features, but with appreciable repetition of subject matter.

I do not propose to attempt to say what should go where, but definitely there should be an understanding among the teachers concerned. Careful study of detailed syllabi of the three courses and friendly discussion may indicate that one or more of the courses can profitably be reduced in clock hours and in credit hours. Or it may be that one or more of the instructors can reduce or delete certain topics and increase or add other subject matter. Unless correlation of courses thus closely related is accomplished, time is wasted in needless duplication, and the student is bored by dulling repetition.

The same sort of co-operative discussion is urgently needed in many colleges between teachers of pharmaceutical chemistry and teachers of pharmacy. I have repeatedly listened to pharmacy lectures that were devoted entirely to chemistry, and the same college required extensive courses in pharmaceutical chemistry. There is much chemistry in pharmacy, but the designation of a course should indicate the content reasonably well. Admittedly, designations of courses are of secondary importance. But it is certainly important not to have two or more courses devoted in great detail to the same subject matter.

Summary and conclusions. In summary, and among the conclusions that may be drawn from the preceding discussion are:

1. Three general patterns for chemistry courses are found in the seventy-four accredited American colleges of pharmacy: (a) all chemistry courses taught by staff members of the college (26%); (b) no basic courses taught by staff members of the college, only applied courses in chemistry taught by them (36%); and (c) some but not all basic courses and all applied courses taught by staff members of the college (38%).

2. In every college, didactic and laboratory

instruction is given in general chemistry, qualitative analysis, quantitative analysis, and organic chemistry. In 66 per cent of the colleges, general chemistry and qualitative analysis are combined. In 18 per cent of the colleges, quantitative analysis and drug assay are combined.

3. Biochemistry is now a required course in 66 per cent of the colleges. One year ago biochemistry was required in 49 per cent of the colleges, and at the end of the recent war the course was required in approximately 27 per cent of the accredited colleges then in existence.

4. In every college, instruction is given in inorganic pharmaceutical chemistry, usually without laboratory work. The course may be designated chemistry (48%); pharmacy or pharmacy and chemistry (28%); organic and inorganic chemistry (5%); or absorbed into pharmacy courses (19%).

5. In every college instruction is given in organic pharmaceutical chemistry, usually without laboratory work. The course may be designated chemistry (66%); pharmacy or pharmacy and chemistry (26%); organic and inorganic (5%); or absorbed into pharmacy courses (3%).

6. Sequence of courses in chemistry in relationship to one another is usually logical. Sequence of courses in chemistry in relationship to science courses not chemistry is frequently not logical.

7. Organic chemistry is given prior to the junior year in 88 per cent of the colleges.

8. Detailed analysis of all required courses in chemistry enables a composite portrait to be drawn. In this portrait total clock hours devoted to chemistry are 992, and total semester hours of credit are 39.

9. Required basic courses in chemistry, with the exception of biochemistry, are reasonably satisfactory. Required courses in pharmaceutical chemistry, especially in organic pharmaceutical chemistry, are less standardized than are the required basic courses in chemistry.

10. A higher percentage of teachers of pharmaceutical chemistry have received training commensurate with their duties than for any other area of professional instruction.

11. Courses in biology are frequently given before courses in basic and in pharmaceutical chemistry, which should logically be prerequisites for the courses in biology. The same illogical relationships sometimes exist between courses in pharmacy and courses in chemistry.

12. In many colleges careful and detailed studies are needed for related courses, especially in chemistry, biology, and pharmacy. The aims of such studies should include logical sequential relationships, avoidance of needless duplication, and inclusion of all fundamental principles.

Teachers of basic and pharmaceutical chemistry in our colleges of pharmacy are teaching courses descended from courses in the earliest American curriculum in pharmacy. As pharmacy has grown over the years, chemistry has also grown in response to increasing needs for chemistry itself. Other areas of instruction have also grown along with chemistry. The growth of these other areas has given a second responsibility to teachers of chemistry -- the responsibility of planning the courses in chemistry so that they will furnish a strong foundation for biological and pharmaceutical courses in the pharmacy curriculum.

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THE BASIC CHEMISTRY COURSES AS TAUGHT IN A UNIVERSITY CHEMISTRY DEPARTMENT

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There are several ways of teaching the science of chemistry to pharmacy students. Chemistry and pharmacy subjects can be presented separately, as they are here at the University of Michigan, or both subjects may be integrated into each of the courses that the student takes. The fundamental chemical facts which are given to the students under any system are probably quite well standardized, however, and the principal differences lie in the number and nature of the variants that are introduced. There are schools of pharmacy which offer their own courses in chemistry for pharmacy students only, and such courses given in such institutions would probably be given with quite a different emphasis from that given here. In an institution such as the University of Michigan, the Department of Chemistry offers fundamental courses, each of which may be attended by students not only in pharmacy but also by those in engineering, premedical, predental, professional chemistry, and general science programs.

It is my understanding that I am to discuss the type of chemistry courses which are elected by the College of Pharmacy students here, and that other speakers will describe the other type. Still other speakers on the program will discuss courses covering specific fields, such as general chemistry, analytical chemistry, and organic chemistry, so that I shall limit this talk to the broader aspects.

When organizing any chemistry program in pharmacy, one must consider the viewpoints of the pharmacy faculty, who are responsible for the complete training program, of the chemistry faculty, and of the students.

Students differ among themselves in their ideas about courses. Some students feel that any descriptive or preparatory material that does not appear to them to have a direct application to their own field is, ipso facto, irrelevant, unimportant, and uncalled for. They immediately set up a mental block that makes it very difficult for them to study and learn those parts of the course. Unfortunately, the student is often unable to judge the importance of the individual topics and many times, because of his hostile attitude, makes a much harder job of learning the subject matter than he should. This is particularly true in regard to the amount of memory work which is necessary before he can begin to understand such a science as chemistry.

It has always been my personal feeling that the study of a science is no different than the study of a language. The chemical language is a live and working language which is constantly undergoing change and even includes terms corresponding to idioms and slang. The symbols in chemistry must be memorized just as a foreign alphabet must be learned. The formulas for hundreds of chemicals must be instantly available as a vocabulary. The basic chemical equations may be compared to the assembling of words into grammatically correct sentences. The selection of a proper group of chemical reactions and their use in a correct order leads to the synthesis of a new chemical in the same way that a new story results from the grouping together of a properly chosen set of sentences. In all these applications it is apparent that a tremendous amount of material must be memorized and available almost automatically if an intelligent and intelligible result is to be achieved.

In the study of pharmacy the majority of students are probably uncertain of their ultimate professional goal throughout a considerable part of their college careers. They need basic training in both chemistry and pharmacy which will allow them after graduation to move either into manufacturing, wholesale selling, retail selling, or research programs. The chemistry courses must therefore be laid out to cover basic principles and fundamental facts. In outlining courses here, our instructors are constantly forced to consider the need of these fundamental factors because of the diverse character of the student body. It is also apparent that in presenting a course to students with such varied interests, it is not possible for the instructor to keep pointing out to each student why it is necessary for him to learn the specific material being presented. The processes of making compounds, whether from naturally occurring ores or from "coal, air, and water", are equally important to chemists, chemical engineers, and pharmacists. The procedures require a series of consecutive chemical reactions, each of which is essential to attaining the desired end, and these factors must be learned if a clear understanding is to be gained. The isolation and consequent purification of chemicals from mixtures, whether involving distillation, crystallization, extraction by the principles used in the Soxhlet extractor or the reverse process involving adsorption that is used in chromatographic separations, are important procedures for all.

The subject of chemistry is now so broad that we have to give general introductory courses followed by many specialized ones, including qualitative and quantitative procedures, organic chemistry, and physical chemistry. As in pharmacy, where the fields are so extensive that only a trained pharmacist with years of study and experience can sift out the salient points of pharmacy for classroom use, the trained chemist is in the best position to judge not only what are the important chemical facts today but also what fundamentals should be presented to help the student understand what may be developed in the near future. It is in these latter areas that the student is most likely to underestimate the importance of the subject matter. We must assume that each student has been given an orientation program in which the ideals and aims of his chosen curriculum have been explained. Furthermore, at the University of Michigan we are dealing with students who have been admitted to the University only after careful screening, including recommendations from their high schools, so that the members of our classes should have enough intelligence to realize that their instructors do not have time to teach everything and consequently must have selected the subject matter only after careful consideration of many factors.

Our aim here has been to present the fundamental facts of chemistry, including, as incidental material only, chemical engineering, biochemistry, pharmacy, medicine, and other related subjects. This is in line with the desires of the faculty of the other departments who prefers to teach the specialized applications as separate courses based on the fundamentals we have attempted to implant in the students' minds.

The members of a faculty of a college of pharmacy are responsible for the integration of material from the several courses into a unified program. In this University they must consider the type of material given in our chemistry courses and then, in courses given under their jurisdiction, show how to apply this chemical knowledge as well as biochemical, pharmacological and similar information to the solution of pharmacy problems.

In pharmacy as in chemistry, chemical engineering, and other related fields, the amount of new specialized information is increasing at a fantastic rate. Unfortunately, in some places, there are attempts to present too much of this new information to the student immediately, and there is a tendency to include it in the program at the expense of fundamental material. The danger in this tendency is that the student will acquire considerable factual material which he cannot understand and which will not help him to be able to foresee or understand new developments. For instance, it is very desirable that the student know about the chemical nature of amides, amines, sulfonic acids, and their derivatives, which knowledge would aid him to recognize and evaluate the chemical nature of sulfanilamid. With such a fundamental background he would be able to make estimates about the solubility and hydrolytic tendencies of this drug and its related compounds. The chemical reactions of the sleep-producing barbituric acid derivatives are related to those of amides, to keto-enol tautomerism, and to other concepts developed from the reactions of simpler compounds. It would be possible to expand these examples to include hormones, vitamins, and other important pharmaceutical materials to illustrate that the elucidation of their chemical properties involves the reactive chemical groups included in their chemical make-up. These properties determine the stability, the compatibility, and other factors about compounds which are intelligible to the pharmacist who has acquired the fundamental information.

It is always desirable to have a certain amount of repetition of fundamental material. Since the acquirement of the basic information and its application are largely dependent upon memorizing a great deal of factual material, it stands to reason that the student is more likely to remember that part of the science which he has been taught from two or more viewpoints -- for example, those of the chemistry teacher and of the pharmacy teacher. From the standpoint of efficiency, however, there should be careful integration of the subject matter in the courses given in the several departments. The faculty of the College of Pharmacy here at the University knows that its students have been exposed to good, sound courses in chemistry. It can, therefore, stress the aspects involving pharmaceutical applications in its courses to the mutual advantage of both student and instructor. We know this is a fact because of the excellent records made by many of its students.

In summary, the advantages of a pharmacy program set up like that at the University of Michigan lie in the fact that the students are taught the fundamentals of chemistry by professional chemists and the fundamentals of pharmacy by professional pharmacists. Because of the diversity of students enrolled in the chemistry courses here, the subject matter has to deal with fundamentals and cannot be slanted toward any one specialized group. Similarly, the pharmacy faculty is able to concentrate on the application of pharmaceutical principles, knowing that the students have had a good chemistry background.

In closing may I state that the results attained under any arrangement are very dependent upon the caliber of the faculty and of the student body. When both are good, the future of the pharmacy profession will be assured, regardless of whether the subject is organized as it is here or all in a department of pharmacy.

THE BASIC CHEMISTRY COURSES AS TAUGHT BY THE DEPARTMENT OF CHEMISTRY IN A COLLEGE OF PHARMACY

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Basic chemistry courses may be considered as general chemistry and analytical chemistry. The general chemistry further divides into inorganic and organic chemistry. The analytical chemistry is considered as qualitative and quantitative. In the careful reading of the catalogues issued by the various colleges of pharmacy, it is apparent that these courses are always included in the curriculum for the student of pharmacy.

Among the courses mentioned above, some are taught by the department of chemistry, the department of chemistry and chemical engineering, or the college of liberal arts and sciences. Other colleges have certain members of the faculty from the college of liberal arts and sciences or from the department of chemistry assigned to the college of pharmacy for the purpose of instructing in these courses. Finally, there is the group that presents these basic courses within its own four walls and by its own faculty.

I have no intention of being unkind or hypercritical of any college or any course within that college. I fully realize that the university, by reason of custom, expediency, or for other reasons, may insist upon having all basic courses in chemistry presented within some single department. One is aware of the existing belief among many educators that only in the department of chemistry within a college or university can they find men with the latest information dealing with chemistry, and thus these men should be selected to present the various courses in this subject. I feel that these educators are wrong in this matter. The men trained in pharmacy, with graduate degrees in chemistry, have a knowledge of chemistry at least equal to, if not greater than, the knowledge possessed by those trained only in chemistry. Many will argue that the basic laws and concepts of chemistry are the same irrespective of who teaches them or where they are taught. That is true, but successful teaching requires motivation. The teacher with the pharmacy background illustrates these basic laws and concepts with examples that make the student constantly aware of their relationship to pharmacy. A teacher so trained inspires and motivates his students to a degree not otherwise attained.

The Department of Chemistry at the Massachusetts College of Pharmacy has eight full-time teachers, and all but one of these are graduates of a college of pharmacy. In addition there are five fellows in chemistry doing graduate work, and each of them assists in not more than two courses. We also have two undergraduate assistants to help with the routine work of the department. Four, and in some cases five, members of our staff, only one of whom is a graduate fellow, assist in each of the required undergraduate courses. The laboratory work is scheduled for the entire class, and assignments are completed only during these scheduled hours. We feel that this ensures adequate supervision and presents a maximum opportunity for instruction in the assigned work.

The person in charge of the individual course gives the lectures and usually prepares the quiz which is given during the recitation and discussion period. He is also responsible for one of the three or four sections into which the class is divided for the quiz and discussion. The laboratory work is under his supervision, and he is present as one of the teachers in the laboratory. I have previously indicated that the class is divided into three or four quiz sections and that one of these sections is under the supervision of the person in charge of the course. Each of the other sections is assigned to a full-time member of the staff, and no teacher has the same quiz section for more than two consecutive weeks. These same men also instruct in the laboratory work. The graduate student or fellow in the course assists in the laboratory and is always present as an observer in one of the quiz sections. After a period of time as an observer, he is permitted to assume charge of the section, but only in the presence of one of the more experienced teachers. During his second year as a fellow, he may be assigned to a quiz section of his own. This is done to provide extra and smaller quiz sections and is not intended to replace any of the regular teachers in the course.

The preceding paragraphs have given a general picture of our teaching procedure. I shall now briefly outline these basic courses and indicate something of the methods employed in presenting the subject matter to the student of pharmacy.

Inorganic chemistry. 3 1/2 class hours and 3 laboratory hours each week during two semesters. A total of 9 credit hours. Textbook, Smith's College Chemistry. This course considers the fundamental laws and theories of chemistry. A study is made of the important elements and compounds, with special

emphasis directed toward those used in pharmacy. Laboratory practice supplements the work in the classroom. Dr. C. W. Bauer, who is in charge of this course, gives the following examples of the pharmaceutical applications of some fundamental principles taught in the classroom and reemphasized by means of actual experiments in the laboratory:

1. Heat applied to an acid salt of an alkali metal gives a normal salt of the corresponding alkali metal. The attention of the student is called to the danger of sterilizing a solution for injection if that solution contains sodium bicarbonate. Ways and means of overcoming this inherent danger are explained.

2. Heat applied to an alkali salt of an organic acid yields the carbonate of the alkali metal. It is used in the assay of Seidlitz powder and other official compounds containing such alkali salts.

3. The hydrolysis of salts made from strong acids and weak bases or from strong bases and weak acids.

$$NH_4Br + H_2O = \text{weak base} + \text{strong acid}$$

The incompatabilities caused by such compounds are illustrated by calling attention to a prescription containing sodium luminal and ammonium bromide. What happens and how can it be avoided?

$$NaAsO_2 + H_2O = \text{strong base} + \text{weak acid}$$

The incompatabilities of Fowler's solution. What happens in a prescription calling for Fowler's solution and an iron salt? How can this incompatability be avoided?

4. Nomenclature. Particular attention is given to irregular nomenclature, showing that it is one thing in chemistry and something different in pharmacy. Some examples are ammonium carbonate, sodium phosphate, sodium borate, magnesium oxide, and calamine.

5. Oxidation and reduction reactions. Examples, the preservation of iodides or reducing free iodine to HI. The use of sodium thiosulfate in neutral medium and hypophosphorous acid in acid medium. When ammonia water may be used, and how oleic acid works.

These few examples are but a small proportion of the many used to emphasize fundamental principles of general chemistry. Thus, the student becomes increasingly aware of the fact that the principles being studied are of very real value to the pharmacist.

Qualitative analysis. 1 didactic and 3 laboratory hours each week during two semesters. 4 hours credit. Laboratory Manual, Evans, Garrett, and Sisler. Textbook, Prescott and Johnson's Qualitative Chemical Analysis. In this course the laws and theories of inorganic chemistry are illustrated and employed in the separation and identification of the more important cations and anions by semimicro methods. As each metal and acid is discussed, attention is called to the compounds used in medicine. The student prepares a list showing the official compound containing each cation and/or anion studied. He is also required to include the official requirements, synonyms, and the solubility of the compound in the common solvents. The need for clear thinking is emphasized through problems such as, "Why is reagent (a) used?"; "What causes such a reaction to occur?"; and "The compounding of the following prescriptions involves certain reactions observed during your laboratory work. Comment on each prescription as to the chemical changes which occur, the cause for these changes, and the appearance of the final product."

The laboratory work of the first semester and a part of that for the second semester consists of the preparation of various test solutions, characteristic reactions, including those of the Pharmacopeia and National Formulary, on known samples, and the separation and identification of unknown samples; at least 18 such "unknowns" are assigned. During eight weeks of the second semester several official compounds are tested for identity and purity by the methods described in the Pharmacopeia and National Formulary. These official tests include the "limit of sulfate and chloride" and the heavy metals and arsenic tests. Through specially prepared samples the student determines the parts per million of sulfate, chloride, arsenic, and/or heavy metal present in the assigned sample. Only one report on each sample is required, and accepted, and two laboratory periods are allowed for the completion of the test. This report is graded, corrected, and returned to the student. The laboratory grades count as 50 per cent of the grade given in the course. Five so-called "practical examinations" are given during the year. Books may be used for these examinations, and a time limit of either two or three hours is set. Three of these examinations deal with unknown solutions containing the anions, the cations, and the cations and the anions. The other two examinations are on unknown official compounds for identity and for identity and purity. This is usually a single sample, with one laboratory period assigned for the completion of the work. The average individual grade for these five examinations count as an extra midsemester examination.

Four written examinations are given during the year. On the fourth and final examination the student is permitted to use all books and notes, but the examination must be completed within two hours. The questions for this examination are derived almost wholly from the Pharmacopeia and National Formulary.

Organic chemistry. Didactic, 3 hours, and laboratory, 6 hours, each week during two semesters. Text, Organic Chemistry by E. V. Lynn. A comprehensive course in which the theoretical principles are studied intensively. In the laboratory, practice is given in the manufacture, identification, and purification of important substances. Professor Matthes

is in charge of this course. He was asked for comments concerning the teaching of organic chemistry to students of pharmacy, and I am happy to pass these comments along to you.

Organic chemistry should be taught as such, but for each illustration the teacher should use an official compound or a compound used in medicine. Even if the course is given very early in the curriculum, most of the students will recognize these compounds as ones that they have handled in a drugstore. A few illustrations will show how this may be accomplished.

1. In studying the saturated hydrocarbons the student of pharmacy is not interested in the cracking of gasoline or any of the other phases of petroleum technology. He is interested in benzine (petrolic ether) as a solvent, the various mineral oils, petrolatums, and paraffin. Neither is he interested in their reactions except for chlorination. How better could this reaction be illustrated, with all its disadvantages, than to show the preparation of chlorinated paraffin.

2. Alcohols. Ethyl alcohol, isopropyl alcohol, and amylene hydrate serve very nicely as typical examples of primary, secondary, and tertiary alcohols.

3. Esters. There are many official esters, such as ethyl acetate, acetylsalicylic acid, and phenyl salicylate. After the group has been introduced and the student knows the functional group involved in an ester, his interest in the subject will be heightened by using these compounds to illustrate the systems for naming the compounds and for their reactions.

4. The reactions of various functional groups can be illustrated by material from the official texts as in the equation:

$$CH_2 = CH_2 + H_2SO_4 = CH_3 - CH_2 - OSO_2OH \text{ or}$$
$$CH_2 = CH_2 + Br_2 = CH_2Br - CH_2Br$$

These reactions are more interesting for a student of pharmacy if he works them out from the official identification tests of the U.S.P., such as:

A. "Ethylene is slowly soluble in sulfuric acid but is rapidly absorbed by fuming sulfuric acid ----."

B. "Bubble ethylene through bromine T.S.: the reagent is decolorized."

5. The dry subject of phenols dissolving in bases can be made interesting by using as an example the assay of oil of clove. Hydrolysis becomes interesting as a method of assay for acetylsalicylic acid. Acetylization under assay for total menthol in the monograph on "Peppermint Oil" brings the subject of organic chemistry right to the pharmacist.

6. Such subjects as optical isomerism, asymmetric carbon atoms, geometric isomers, and D and L configurations all play a very important part in pharmacy. Why not use official substances to illustrate these terms? Tartaric acids provide an excellent means to discuss the idea of asymmetric carbon atom and optical isomerism. Most of the alkaloids have asymmetric carbon atoms. Atropine, the inactive form, and hyoscyamine, the active form, can re-emphasize this point. Geometric iromers, due to the rigidity of a double bond or ring, can be brought out under oleic acid and under diethylstilbestrol. The D and L configurations of the sugars can be discussed under dextrose where the Pharmacopeia gives D-glucose as a synonym. Again, they may be discussed under chloramphenicol. One very important point should be remembered. Most courses in organic chemistry do not treat heterocylic compounds to any great extent. From the point of view of the student of pharmacy this is a grave error since many of our most important drugs, the barbiturates and the alkaloids, fall under this classification. Less time should be spent on aliphatic compounds and more time on the heterocylic compounds.

The subject of quantitative analysis will be considered later in this Seminar.

I have endeavored to present a general outline of the methods used at the Massachusetts College of Pharmacy for the teaching of the basic courses in chemistry. The courses so taught are intensive and comprehensive and include the material presented in any course given under the general titles of the basic courses. We have often checked the course content through the examinations prepared by the American Chemical Society, and our students do exceptionally well in these tests. Any student becomes increasingly interested in the course work required of him if he can see some relationship between that required course and his professional training. Thus, the teacher of basic chemistry, with a knowledge of pharmacy and by using examples of pharmaceutical importance in his teaching, presents the subject matter of his course in a manner that will inspire the student of pharmacy and motivate learning in these courses.

IMPROVING THE EFFECTIVENESS OF COLLEGE TEACHING

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Most college teachers doubtless consider themselves to be effective teachers, and some would rate themselves as especially good. Such flattering self-evaluations are not surprising, since few college teachers have ever had their instruction appraised by students or colleagues, and few have ever been required to submit any evidence of their effectiveness in the classroom. The writings of college teachers are critically appraised by colleagues in their own and other institutions; reported research is evaluated by other scholars, and the quality of professional leadership is well known to associates. But success in classroom teaching is rarely subjected to critical appraisal. Too often college teachers seem willing to admit their neglect of teaching, and some appear to resent the suggestion that they should be actively concerned about instructional problems. While many of them are justly proud of their contributions to scholarship, they seem unwilling to assume any responsibility for the lack of studies of the teaching problems in their fields of specialization.

The writer is convinced that there is much teaching of superior quality in all colleges and professional schools, as well as some fair or even poor teaching. My viewpoint is that inadequate efforts are made to eliminate poor teaching, that too little recognition is extended to staff members who excel in classroom instruction, and that some colleges and departments fail to create conditions favorable to a high quality of teaching.

In a recent study by the American Political Science Association there is an instructive chapter entitled "Modernizing Teaching Methods." Two quotations from this chapter support the viewpoint that college teaching is a neglected area of inquiry on the part of competent scholars. One college professor is quoted as follows: "Much can be done with the use of slides in the handling of governmental materials of a descriptive nature: graphs, power listings, financial figures, etc. Not much is done on this by most people, because it takes imagination and gets no promotion." (1) The comment "it takes imagination and gets no promotion" does not reflect favorably on college teachers or administrators.

This discouraging note is sounded in the chapter: "In general, standard educational practices of fifty years ago still prevail. Except for the fact that postwar enrollments caused classes to be larger, the instructional technique of the lecture section, with the smaller discussion group or quiz section for the beginning course and the seminar room for the most advanced graduate courses, is still current procedure." (2)

A working definition of effective college teaching might well involve success in efforts: (a) to insure mastery of the essential skills and basic facts in a given field as well as the development of the ability to apply these to significant problems; (b) to strengthen the interests and habits required for continued independent study and investigation; and (c) to cultivate such desirable civic attitudes as honesty, dependability, resourcefulness, and co-operativeness.

The urge to do effective teaching can be strengthened by the college administrators. It is unfortunately true that some officials seldom make any references to the importance of classroom teaching but emphasize other aspects of a professor's work, such as research, writing, and professional leadership. It is granted that no college can build a reputation for distinctive quality without considerable emphasis on writing, research, and professional leadership; but no college can serve the students as they should be served if it neglects efforts to maintain a high level of classroom efficiency.

Many institutions engage sporadically in efforts to improve the quality of teaching. These efforts are sometimes quite ineffective because of certain ill-founded and erroneous opinions regarding college teaching that are held by some staff members. Among these opinions are the following:

1. The erroneous opinion that an instructor who possesses high scholarship can, therefore, teach effectively without any continuing consideration of teaching problems.

2. The ill-founded belief that it is beneath the dignity of a college instructor to seek to develop student interest in his courses through attention to the psychology of learning.

3. The thoughtless supposition that the staff member who engages in writing and research is likely to be a poor teacher or, conversely, that the staff member who does no writing and no research is certain to be a competent teacher.

4. The misguided notion that the lecture method is the only suitable procedure for instruction at college level.

Such mistaken opinions discourage efforts to improve college teaching because their acceptance relieves instructors of any feeling of responsibility for

appraising teaching techniques and for seeking to develop better methods.

It is very doubtful that college instructors would be likely to improve their teaching through a series of lectures on the art of teaching, especially if attendance were made a requirement. What is needed is a willingness on the part of instructors to review critically their own procedures, plus a willingness on the part of instructors to make improvements in terms of their own evaluations and experimentations. To stimulate a review of teaching techniques, lists of good practices may be used to advantage. These lists may well be prepared by a staff committee in a selected field. To indicate some of the statements that might appear in such a list of good practices, the writer has prepared a summary of the practices of successful college teachers as revealed in the literature on college problems. A copy is attached to this paper. The list may be used to pool opinions regarding teaching practices or may be used to build a list for a specialized field of instruction. Some of the practices mentioned in the list would doubtless apply in any field of instruction. For example, the second item reads, "They develop adequate outlines for their courses which they revise frequently." It is common talk among college students that professors use the same outlines year after year. The story is frequently told of a freshman who had not purchased an outline for a course. When his professor reprimanded him for his neglect and warned that he might fail the course, the student replied, "My grandfather gave me his outline of this course and I find it very satisfactory. No changes have been made since his days in your class."

In one technical institution it is the policy to have course outlines built by two or three instructors, and several weeks in the summer months are made available for this important work. In this institution course outlines are revised every year.

Item 10 reads, "They exhibit a genuine enthusiasm for the values and worthwhileness of their course." Enthusiasm for learning is contagious, and the instructor who has a real enthusiasm for the worthwhileness of his course is certain to secure much better results than is the instructor that exhibits no such enthusiasm. It is a real tribute to a professor when someone declares, "He could arouse interest in any course because of his genuine enthusiasm for the potential values to be attained through his instruction." Too frequently instructors, especially those in charge of required courses, never attempt to convince students that their courses have other values than those of satisfying the requirements for degrees or for meeting state board regulations.

The last practice in the list reads, "They share with students their own joy in learning, and work with students rather than seeking to impose personal opinions or prejudices on them." Many instructors have found that teaching nets higher returns when they share their joy of learning. Some instructors are unusually successful in convincing students that they are real associates in the search for knowledge.

In a book entitled Great Teachers there is a chapter devoted to Louis Agassiz, the great Swiss naturalist, who came to the United States to investigate the teaching of zoology and then remained here for the rest of his life. As a member of the staff of Harvard University, Professor Agassiz is credited with revolutionizing biological teaching throughout the American educational system. In the tribute to Professor Agassiz emphasis is placed upon his sharing of his own joy of learning. A part of the tribute is as follows: "It was Agassiz's habit to use his students to explore fields for him. This was an inevitable element in his method of teaching, and has been inevitably followed by all inquirers who have taught. In this process of exploration it was his custom to set one of us to work on a group of animals concerning which he had some knowledge, so that he could guide his inquirer, at least at the outset of the investigation... He was as eager to receive as to give, and what I supplied went into his memory as his own discoveries, which in a way they were, for the direction of the work came from his mind...." (3)

As has been previously stated most college teachers could teach better if they really wanted to do so. While some of the responsibility for the development of this desire must be assumed by the administrator, a large measure of the responsibility must rest upon the individual staff members. A staff can be encouraged to devote attention to teaching problems by an administrator who makes clear his opinion that good teaching is highly important and will be rewarded as will writing and research. More important than those tangible rewards are the psychological satisfactions that all persons require: a feeling that efforts are significant, that work is appreciated, and that reasonable security exists. Encouragement to experiment with teaching procedures is a prime requisite for improvement. Faculty growth in teaching effectiveness takes place most frequently in an atmosphere of real co-operation in which administration, staff, and students join in attacking common educational problems. In order to make such an undertaking effective the administrator himself should be an accomplished teacher who seeks to achieve in his staff the same kind of growth in intellectual maturity and truth-seeking that the instructors are trying to develop in their students.

Many college administrators are continuously seeking to improve instruction. Some encourage departments to devote one or more meetings a year to the discussion of effective methods of teaching. Some require the younger staff members to submit occasional statements relating to the aims, the content, and the methods of their courses. In some institutions occasional conferences of staff members are arranged at which a highly competent teacher from another higher institution conducts a roundtable on instructional problems. Other practices may be summarized as follows:

1. In recent years some professional schools have sponsored conferences of staff members for

the discussion of instructional problems with special attention to teaching techniques.

2. An increasing number of colleges are holding preopening conferences at which institutional problems are considered with attention to the improvement of college teaching.

3. National groups in subject matter fields are devoting increased attention to problems of teaching in their meetings and publications. (See the report of the American Political Science Association, 1951.)

4. State and national conferences on problems of higher education are being held at which the preparation of college teachers and college teaching are discussed.

5. A few colleges provide an inservice training program for new members of their faculty in order to give them a good orientation to the purposes and methods of the particular institution, and to provide the means of assimilating them as members of the teaching staff.

6. Some colleges provide a faculty manual designed to give faculty members helpful suggestions. For example, a model syllabus for a course is included as a part of the suggestions for course planning.

7. At the University of Chicago and the University of Michigan an annual award is provided for a staff member who has established a reputation for distinguished instructional service.

8. Some institutions have a central examinations office, staff members of which are available to the faculty to assist them in preparing and validating examination questions and in building up pools of validated questions.

9. In some institutions, an instructor in speech will be made available to the faculty for consultation about effective speaking. This includes the use of recording instruments for playing back to the instructor his own voice.

10. Some institutions designate a faculty member to whom instructors can turn for advice about their teaching.

11. A few institutions have an evaluation service. Its staff is available to any faculty member who desires help in making an evaluation of his work, and at intervals, the service makes evaluations of the program and other aspects of the institution's work.[1]

The foregoing practices are a sample of encouraging trends and developments in higher institutions and may be interpreted as evidence of an increasing concern about improving the effectiveness of college teaching.

College administrators can do much to promote good teaching by emphasizing the importance of teaching. In the fall of 1950 this was done very effectively at the University of Michigan by Dr. James P. Adams, the University provost. Provost Adams sent a communication to the younger staff members in which he said in part:

"We all realize that good teaching is based upon adequate understanding and appreciation of subject matter and method. These are primary essentials but, if they are to be fully effective, they must be fused with other attributes in the mind and spirit of the teacher. One of these attributes is high respect for the importance of the teaching function. Another is considerate interest in the student for whom the educational process exists. And still another is contagious enthusiasm for the field of study.

"If these attitudes find expression in the experiences of your classroom, and if you make the materials of knowledge with which you work objects of lively interest to your students, as they contemplate their educational objectives, you will have fulfilled the highest obligation of the teacher." (4)

A program for improving college teaching might we well emphasize inquiry, experimentation, observation, and evaluation. Instructors should make inquiry regarding the experience of others in the teaching of similar courses. Some of this experience may be found in publications, but much can be secured only by questioning some of the more successful teachers in a field. Instructors should observe the work of other teachers, especially those who have gained reputations for a high quality of teaching. While much can be learned by observing the successes of other teachers, there is too little attention given to such observing. In fact, there are some instructors who resent the presence of visitors in their classes, especially those that are concerned with observing teaching techniques.

Dean Paul Klapper, formerly president of Queens College in New York City, has given much thought to problems of college teaching. He sets forth one of his views in the following statement: "College teaching and student life would take on a new vitality if college teachers and surely all campus 'brass' were required to take at least a Sabbatical semester for visiting sister institutions not less infrequently than the Biblical prescription of once in seven years." (5)

Instructors should take an experimental attitude toward their teaching rather than copy the techniques of associates or following the procedures of former instructors. In the field of scientific scholarship experimentation is given a high rating, and it is proposed that the same spirit of experimentation be carried into the field of teaching. Instructors should evaluate their teaching and review their procedures by the use of check lists. In an increasing number of liberal arts colleges and schools of education faculty members are using student appraisal forms to get an insight into their own effectiveness. At the

[1] In the preparation of this list the writer is indebted to his colleague, Algo Henderson, Professor of Higher Education, University of Michigan. Professor Henderson was formerly president of Antioch College and more recently associate commissioner of higher education for the state of New York.

University of Michigan, students are occasionally asked to evaluate their courses in such units as the Arts College, the Engineering College, the Medical School, and the School of Education. There are critics of this practice who insist that college students are too immature to have worth-while judgments, that their opinions are quite likely to be unstable, and that they tend to reflect in their evaluations their own high or low success in a course. Studies have indicated that student opinions have a relatively high correlation and validity with other estimates of teaching efficiency.

The present concern about increasing the effectiveness of college teaching is most encouraging. In all probability college teaching is much better than the critics would be willing to admit, and it may be that college teachers are too willing to be the target of adverse criticism and too reluctant to come to the defense of their own instruction. It must be admitted, however, that there is a widespread belief that much college teaching is wasteful of the faith, the effort, the time, and the ambitions of students, as well as destructive of intellectual interest and curiosity. The persistent criticisms of college teaching by students and alumni cannot be "laughed off," for colleges are very dependent upon the goodwill of their clientele. The widespread desire on the part of college administrators to improve public relations doubtless explains some of the present interest in bettering the quality of college teaching. In public relations, college teachers are most important agents, and it is a well-known fact that the highly successful instructor contributes much to the improvement of the relations with alumni and friends of a college.

All who are engaged in college teaching could profit by reading and rereading a high tribute to teachers prepared some years ago by George Palmer, who built an enviable reputation as an inspiring teacher. Professor Palmer said in part: "The touch of the teacher, like that of no other person, is formative. Our young people are for long periods associated with those who are expected to fashion them into men and women of an approved type. A charge so influential is committed to nobody else in the community... On school and college instruction the community now bestows its choicest minds, its highest hopes, and its largest sums."

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THE EDUCATION OF TEACHERS OF PHARMACEUTICAL CHEMISTRY

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This seminar takes me back to the day when Dr. Edward C. Elliott and I talked about the recommendations which the Pharmaceutical Survey should make concerning the improvement of teaching in the colleges of pharmacy -- a subject in which he was much concerned. I had previously written a book on teaching in which were described the summer schools for teachers of engineering conducted from 1927 to 1933 and resumed in 1939. Dr. Elliott was well acquainted with that project, for while he was president of Purdue University two of those summer schools were held on its campus. He soon made a proposal to the American Association of Colleges of Pharmacy and the American Foundation for Pharmaceutical Education that they co-operate in the conduct of summer seminars for teachers of pharmaceutical subjects. As a result, these seminars got under way in 1949 with the one on pharmacy at the University of Wisconsin. It is a source of personal satisfaction to me to observe the success of the summer seminar idea for teachers in the colleges of pharmacy.

In participating in this Seminar, I want first to describe the work of the college and the university teacher, to refer to the complex character of these activities, to indicate some of the qualities of mind and heart which help to make a teacher successful, and lastly to suggest the training a college teacher should have with some reference to the teacher of pharmaceutical chemistry.

Work of the Teacher. For our purposes we need to give attention to six different activities and functions of the teacher. The first of these is for him to establish the objectives his students are to attain. Teaching is an activity that is aimed at accomplishing certain goals. Without them it has no direction; it becomes movement without much intelligence and produces limited and uncertain results. Perhaps the sharpest criticism that can be made of a teacher is that he does not really know where he is going or what he is doing. And yet how often the charge is made that what goes on in many college and university classes is essentially aimless and confusing, that much of it is lost in a fog because it is not directed toward the accomplishment of definite purposes.

It is a common observation that there is widespread inability on the part of teachers to state what results are desired out of individual courses. Many teachers have not thought in such terms. They teach what they were taught, what the textbook contains, or what they are interested in at the moment, seldom giving thought to the question: What am I trying to accomplish? What do I want the student to get out of the course? These questions he must ask of himself frequently and answer them intelligently.

Second, the teacher has to prepare his courses. To do this well requires considerable effort and time. To be carried out adequately the comprehensive planning should usually be done during a period when work can proceed on it without hurry or much interruption, and well in advance of the time when instruction begins. It may start with the formulation of the objectives to be accomplished through the course. It proceeds to the preparation of an outline of the subject matter to be used and the things to be done, divided into a series of units of topics that are arranged in logical order and set to the calendar.

A well-designed plan for a course makes teaching an orderly process, assures the maintenance of perspective, helps to place emphasis at appropriate points, and guides the work to the desired conclusion. If the plan is placed in the hands of students, it provides for them a view of what they are expected to accomplish and enables them to co-operate understandingly with the teacher. Such a simple procedure -- workmanlike, systematic, well-ordered -- is much prized by students. It enables them at all times to know where they are, what they need to do. It enables them also to plan their work -- and that is most helpful, for they are besieged by numerous demands, some of which are unanticipated.

And the planning of courses is a never-ending process. The alert teacher is always on the lookout for ways and means to improve his course plans.

The idea I am suggesting here is quite in contrast with what students sometimes report about teachers. I am reminded of the teacher of economics who told a colleague that he could not understand why students no longer filled his classes as they did twenty years ago when he gave exactly the same lectures!

For myself, one of the chief joys of teaching is derived from the planning of courses. I have found it a most stimulating activity, which leads to new insights and develops new perspectives. On a few occasions it has been necessary for me to teach courses which, because of circumstances I could not control, I was not able to plan in advance. On these occasions I was never happy with my work or altogether pleased with the results.

Third, the college or university teacher needs to make daily preparation for the sessions with his classes. A well-planned and prepared lesson is essential to any meeting with a class. The lack of such daily preparation is a common cause of failure. Often it results in much improvising and bluffing on the part of the teacher. He may even sink to the low level of resorting to his own autobiography in order to use up the time.

There are two phases of this daily preparation: the study and review of the subject matter to get it clearly in hand and the planning of the classroom work. The teacher's study of the subject matter consists partly of renewing knowledge he has previously acquired, clearing up hazy ideas, recapturing the details, and getting the relationships clearly in mind. In this study he also may acquire new knowledge and fresh points of view. The planning of the daily work consists in determining the objective of the lesson and selecting or devising the means to be used in realizing the objective. Time allotments may be made to the various parts of the classwork. Leading questions, problems, and exercises should be designed. If illustrative materials are to be used, they should have particular attention in order to assure that they will be on hand at the appointed time and will serve the purpose intended. Such thoughtful daily preparation is a long step toward success in teaching.

One further word regarding this matter. Careful planning is characteristic of sensible and intelligent persons in all difficult undertakings. It is particularly needed in the work of teaching, where one may so easily do the wrong thing, waste time and effort, and fail to obtain the results that should rightly be expected. Only one who is willing to make the necessary preparation should have a place in the classroom as a teacher. Only one who concerns himself with the careful preparation of his courses and of his daily work is likely to generate the enthusiasm that makes of him an inspiring teacher.

Fourth, the teacher conducts the session of the class. Here his work reaches its culmination -- the climax for which he has prepared. It is the supreme test of his resourcefulness and ingenuity. Here, within fifty precious minutes he has an opportunity to achieve great things in the lives of his students. The pity is that so often the opportunity is neither appreciated nor lived up to.

The college and university teacher may employ a number of methods of teaching. He may lecture, he may arrange and direct various kinds of discussion, he may use a question and answer procedure, and he may employ a variety of visual aids and forms of direct experience with objects, situations, and activities. As an accomplished teacher he should be competent to use any or all of them as they appear to be the most appropriate means of accomplishing his purposes. The one procedure that is much overused, grossly abused, and often badly employed is the lecture.

In my opinion a class session should be a cooperative undertaking in which the teacher and the class join with interest and zest. The teacher should work with the class as well as manage it. He should be not only a master but also a comrade. There should always be vital communication between the teacher and the taught.

The teacher should not be primarily a purveyor of information; that can generally be had better from printed sources. His function transcends that of imparting data; rather it is to serve as leader, interpreter, and guide to students as they use information to acquire new concepts, understandings, and insights. Someone has characterized the true teacher as a consulting architect who is assisting the student to build his structure.

The meeting of the class should be primarily an exercise in thinking, both for the students and for the teacher. If it is largely anything else, it is likely to be dull and uninspiring. I like to think of a classroom exercise as an adventure with ideas. What a thrill it affords when conducted in that light!

In the classroom the teacher needs to remember that he is teaching individuals; the group as a group does not learn. May I quote a cogent statement from Professor William Lyon Phelps of Yale University. In his lecture on "The Excitement of Teaching" he says: ". . . . whenever I enter a classroom filled with young men, I think of them not as a class or a group; but as a collection of individual personalities, more delicate, more intricate than any machinery. Not only is every student an organism more sensitive than any mechanical product, every student is infinitely precious to some parent or to some relative who may be three thousand miles away . . . The officials at the United States Mint, the head of a diamond mine, the president of a metropolitan bank are not dealing with material so valuable as that in the hands of the teacher. Their mistakes are not so disastrous as his; their success is not so important." Fortunate indeed is that class whose teacher has such a humane attitude toward its members.

The final test of the class session is the result it has produced. Have the students reached new understandings, acquired new insights, and gained new views and horizons; have they grasped more fully the nature of their undertaking; have they learned to think more clearly and soundly; have they received new inspiration to achieve their best? These are among the solid accomplishments that should flow from the contact between teacher and student in the classroom.

The fifth function of the teacher is to counsel with students. It is true, of course, that a considerable part of the counseling of students is delegated to particular officials, such as deans and faculty advisers, and that is as it should be. But every teacher who is genuinely interested in students and respected by them has many occasions to advise students, sometimes in regard to a particular course, and sometimes about other matters of mutual concern. In an

institution where a large share of the instruction must necessarily be in groups, sometimes large, the contacts between teachers and individual students often become of great significance in the progress of the student. Moreover, these contacts are essential for the teacher who wants to understand his students in order that he may serve them well.

The sixth part of the teacher's work is to evaluate the accomplishments of his students. I need hardly remind you that a test or an examination should be an effort to discover whether students have accomplished the objectives set for them. That being the purpose, the examination questions should be definitely based upon the objectives. All too often the questions have no particular purpose other than to sample the student's information.

The examination, like every other phase of the teacher's work, should be carefully planned. The preparation of sound examination questions is not an occupation for an amateur. In doing it there is much at stake, both from the point of view of sound education as well as from the point of view of justice to students.

In recent years test experts have developed an extensive set of ideas and principles regarding examinations. Today no teacher need be uninformed about good practices in the examination function.

Up to this point I have tried to outline briefly the work of the college or university teacher as I see it. This work, if it is well done, makes heavy demands on him. It is necessary that he begin with a wealth of resources, that he shall replenish those resources as he goes on with his work, and that he shall possess a continuing enthusiasm for his work.

Equipment of the College Teacher. Let us now look briefly at the equipment a college or university teacher should possess. When one considers this matter, he usually thinks first of scholarship, that is, a mastery of the knowledge and skill which is to be taught. This equipment is absolutely essential; without it the blind try to lead the blind, the ignorant attempt to direct others who are likewise ignorant. Surely it is not possible for one to teach his students adequately unless he himself has first become a master of what the students are called upon to learn.

But it is not enough that one shall know the subject matter he teaches; he should have gone far beyond this point. He should have proceeded to the place where he has acquired a broad perspective in his field, a comprehension of his subject in its various relationships, and ability to think constructively in his field of learning. Moreover, his scholarship should have a dynamic quality -- ever expanding and renewing itself as he continues his work of teaching. In short, he should have reached the point where he is no longer a mere imitator of others, but where he speaks in his own right and from firsthand direct experience in his field of learning.

Teaching is creative work which calls for broad and profound scholarship. Let me digress briefly here to consider the meaning of scholarship. It is necessary for our purposes to distinguish between two terms -- scholarship and research. Here I want to quote a helpful statement from Professor W. H. Cowley of Stanford University:

"Research is the effort to discover new facts or to recover lost or forgotten facts: it is the empirical element in the quest for understanding the nature of the universe and of man.

"Scholarship is the organization, criticism, and interpretation of facts and thoughts about facts: it is the rationalistic element in the pursuit of understanding. These two activities, I would reemphasize, supplement one another, depend upon one another, require one another. To prosper they must fertilize each other; and if one suffers, so also does the other. I would also reemphasize what seems to me to be a fact of the expanding complexity of knowledge; that few men can be both research scientists and interpretive scholars and that therefore we have been forced to specialize the two functions. Yet empirical research workers and rationalistic scholars must work together cooperatively fructifying their different but inter-dependent duties.

"The definitions just given make it possible to move on to the appraisal of the relation of the higher education to each of the two segments of the higher learning, the empirical or research segment and the rationalistic or scholarly segment." (1)

Professor Cowley then goes on to speak of the relationships of research, scholarship, and teaching by saying:

"To perceive these three processes clearly also leads to the awareness that research per se has no direct relationship to teaching and that scholarship must stand between them and join their hands. Before research data become teachable, they must go through the intermediate stage of scholarship, the stage of arrangement, criticism, and explanation. This means that everyone who is to devote his major energies to college teaching should be trained in the skills of scholarship and that the primary emphasis in his graduate training should be, therefore, upon the organization, criticism, and interpretation of the facts turned up by research people. This will involve enough association with the research enterprise to understand both its insistent importance and its methodology, but it need not involve concentrated and continuous participation in research investigations. Instead, attention must be directed to scholarship per se and also to the acquisition of skill in communicating the results of research and scholarship in able teaching. People can learn to teach, but such learning must rest upon the foundation of sound and continuous scholarship.

"Those who proclaim that no one can be a good teacher unless he does empirical research simply ignore the abounding evidence that many great and good teachers are not research men and never have been. Yet these critics of 'mere teaching' and 'mere teachers' would be as right as truth if they would modify their statement to read: 'No one can

be a good teacher unless he keeps continuously organizing, criticizing, and interpreting the data, new and old, of his subject -- unless, in short, he's a scholar.'" (2)

We do well, then, to differentiate between empirical research and rationalizing scholarship. We have a conflict today because there are those who would emphasize research largely to the neglect of interpretive scholarship. Only scholar-teachers are likely to be good teachers.

The second aspect of the college or university teacher's equipment should be an acquaintance with pedagogical method and considerable skill in using it. He needs to know how a student learns his subject -- chemistry, for example -- and how it can best be taught. A very common cause of failure in teaching, as is clearly shown by objective studies at both lower and higher levels of teaching, is the use of poor teaching methods. These inadequate or wrong methods are nearly always the result of a failure to understand the principles of learning and a failure to organize learning experiences in such ways that students can comprehend them. In some academic quarters one notes a disposition to deny the importance of methods of teaching, a disposition not so much in evidence now as formerly, since students are becoming more outspoken in their criticism of teachers who have not acquired the art of doing that for which they are paid. Nevertheless, one would hardly be warranted in saying that the study of methods of teaching is wholeheartedly accepted as an integral component of preparation for college and university teaching. Indeed, the most marked defect in the preparation of college and university teachers is the lack of effort devoted to the specialized activities of teaching. It may be true that a few human beings are born with a genius to teach, but the great majority of those who aspire to become good teachers must learn the art through study, observation, and practice, just as one learns to do well any complicated activity.

Third, one may have acquired sufficient scholarship and a considerable knowledge of how to teach, together with some skill in using both, and yet be a poor teacher. He may not be an effective teacher because of a lack of an elusive factor, which, for want of a more precise term, is generally called personality. Sometimes it is pointed out that too many teachers are colorless, queer, poorly adjusted, self-centered, and ungenteel in act and manner.

The personality of the teacher, like his scholarship and his pedagogical competence, bears directly on how he fulfills his functions. One who is friendly, sociable, and interested in people, and particularly in students, will teach very differently from one who is unfriendly, conceited, and selfish. Certainly a teacher who lacks interest in his work and whose mental activity is sluggish and dull will not perform his functions in the same way as one who is enthusiastic about his work and whose mind is keen and alert.

These three aspects of the equipment of a good college or university teacher, a teacher of pharmaceutical chemistry -- scholarship and skill in his subject or field of instruction, acquaintance with pedagogical method and skill in its use, and a pleasing and inspiring personality -- constitute essential factors in his success. They go a long way to ensure satisfactory teaching service.

Education of teachers of pharmaceutical chemistry. A significant step in developing teachers of pharmaceutical chemistry is to find the right persons. In my judgment the faculty of a college of pharmacy should always be on the alert to discover among the undergraduate students those who have a possibility of becoming good teachers. As soon as such a student is found, he should be encouraged to consider a career of teaching.

As far as possible, the undergraduate education of a prospective teacher of pharmaceutical chemistry should develop in him those qualities, interests, and abilities that will contribute directly toward a teaching career. Certainly, a liberal amount of education in the humanities and the social sciences is most desirable. Indeed, I regard it as essential for one who is going to be a teacher of young people preparing for any profession. Moreover, the undergraduate education should have been acquired with a good record. Both of these elements -- a broad general education and a good academic achievement -- become the foundation, and deficiency in either will surely prove to be a handicap to a teacher. Graduate education does not aim at patching up deficiencies and shortcomings of the foundation, and it will not succeed in doing that.

The undergraduate education of students who plan to take graduate work in order to become teachers of pharmaceutical chemistry should be adapted to their particular needs. Certainly, courses in a modern foreign language, the calculus, and physical chemistry should be a part of the undergraduate curriculum for such students. Time for such courses might be had by omitting for these students some or all of the courses in pharmacy administration. Substantial courses in English composition and public speaking are essential. Some undergraduate study of educational psychology and education, as electives, would be helpful by way of developing in the student some acquaintance with educational work.

Do I hear someone say that such a foundation as I am suggesting for graduate study cannot be provided by the current four-year undergraduate curriculum in pharmacy? I fear your contention may be well founded. I believe, however, that before too long the undergraduate curriculum in pharmacy will be lengthened by adding one or two years of prepharmacy education. When that is done, the students can be well prepared for graduate study.

Graduate education in pharmaceutical chemistry is generally regarded as a sine qua non for teachers of the subject. We are approaching the time when the degree of Doctor of Philosophy will be the

common requirement. Of what should this graduate education consist? What should be its character?

The major part of this education, I take it, should be an effort to make of the student a reasonably accomplished scholar in the field of study he will teach. To this objective he will devote his major effort.

In recent years we have been hearing a good deal of criticism of the programs of the graduate schools with respect to the preparation of college and university teachers. Two weaknesses are pointed out. First, it is said that graduate students are too narrowly educated to become good teachers of undergraduate students; they specialize too highly. Graduate students, it is said, lack ability to see the relationship of their subject to other subjects; they are unable to synthesize knowledge; they are not able to relate the material in their own specialities to cognate fields or interpret the meaning of their subject in terms of the wider area. Not only do the graduates not know the materials in cognate fields, but they are not interested in them. After these students become teachers their teaching, it is said, is pitched to the level of specialists rather than to the level of students who are but building the foundations of understanding in a broader field. There is no doubt that the high degree of specialization may be appropriate for one who plans to spend his life as a research worker but not for one whose primary work will be to teach.

The second weakness of a great deal of graduate education from the point of view of developing teachers is that the interest of the graduate school is centered in research and developing research workers rather than in teaching and making good teachers of the students. The criticism is made that the current emphasis on research in the Ph.D. programs tends to steep the graduate students "in the idea that their satisfaction as well as their rewards will come from research rather than from teaching." Young teachers prepared in the graduate schools, it is said, "look upon their period of undergraduate teaching as a necessary and not too pleasant experience through which they must go on their way to a professorship which they hope will be devoted largely to research." (3)

I believe there is no question that training in research, if not too narrowly conceived, is important for prospective college and university teachers. As a method of study it should be understood and appreciated by all of them. Its principal function is to teach students how to obtain and use evidence. I shall probably never forget a casual remark of my major professor at the University of Chicago when we were talking over my dissertation. He said he had long ago come to realize that the main objective of the dissertation should be the training which the student receives rather than the original contribution to knowledge which a dissertation is presumed to make. That remark suggests what I regard as a sound point of view concerning the place of research in the preparation of a teacher. The search for truth is the responsibility of everyone who deals with ideas and who teaches young people; he should know the problems involved in seeking out truth, in discovering facts and interpreting them. It seems reasonable, therefore, that all graduate students planning to teach should actually engage in a sufficient amount of research to learn its methods and understand its meaning.

I would suggest, however, that the idea of research should be extended and construed with some insight and imagination if it is to provide for the prospective teacher the opportunity that will serve his purposes well. He should be called upon to demonstrate that he is interested in and able to engage fruitfully in interpretive, independent study. Here I should want to follow a recent report which says:

"The kind of research a man should engage in should be determined by his particular interests and capacities. If he has a capacity for detail and for finding and using knowledge of this sort, his work should be planned to make sure he has an opportunity to do something worth doing that uses these interests and capacities. If he has a capacity for organizing, synthesizing, and interpreting knowledge and ideas, his advisers should see that he has an opportunity for work which uses and develops these capacities." (4)

This same report sums up the academic preparation of the teacher in three statements: (a) The prospective teacher must have a thorough knowledge of his subject and its relation to knowledge as a whole. (b) He must have mastery of the necessary tools and techniques to acquire sound knowledge of his general subject and to engage in original and creative study of the subject. (c) He should have successful experience in the kind of independent research which not always seeks new information but which may evaluate and interpret knowledge as it relates to human experience.

And now a brief word about the pattern of study for the graduate student who expects to become a teacher. Some years ago it was quite common for the student to select a major field and one or two related minor fields for his study. In some instances the courses were prescribed and the student was expected to adhere rigidly to the pattern. Today, it is a common practice to organize the graduate student's program, especially at the Ph.D. level, largely on an individual basis according to his objectives, interests, and abilities. The success of such a flexible program depends, first, upon whether the student has a clear objective and some conception of how to accomplish it, and second, upon the wisdom and patience of his faculty adviser or advisers.

Such a plan seems to me to be the better one to follow in preparing teachers of pharmaceutical chemistry. From the varied resources of a great university or college -- and no other should undertake graduate instruction to prepare teachers --

the student and his advisers may select those courses in chemistry, physics, biology, and perhaps other fields that will help him to become a creative scholar who has a broad perspective of his field and an understanding of its relationships to the profession of pharmacy and to a very complex civilization.

What preparation should be provided for the prospective teacher of pharmaceutical chemistry with respect to pedagogical competence? In my judgment it should include some study of educational psychology and its applications to teaching. It should deal also with methods of teaching in higher education, including educational measurements, which might well take the form of a seminar conducted jointly by subject matter specialists and educationists. Some supervised experience in teaching chemistry to college students would constitute a most valuable asset. A course on the nature, purpose, organization, and administration of pharmaceutical education would also be useful for the prospective teacher. The work in pedagogical subjects need not extend over more than eight or ten semester hours of credit. It should not be difficult to include such an amount in the program.

Teaching under supervision should be organized to afford experience with the various types of teaching activity. Many graduate students hold fellowships and assistantships for which they render certain services, but generally these services are not sufficiently varied nor significant enough to provide the experience which the prospective teacher should obtain. Furthermore, the supervision is often not sufficient to assure the best results. Appointments to these places are not customarily made to help train the students who are preparing to teach, but rather to supply needed staff for undergraduate teaching or to provide financial aid to students.

I would suggest that graduate schools which train teachers of pharmaceutical chemistry should use their resources, fellowships, and assistantships to provide substantial experience in teaching for students who expect to become teachers.

Lastly, we ask, what can be done to improve those personal traits and characteristics of graduate students which make for success in teaching? This question is difficult to answer, and few have attempted it. Certainly, the pedagogical courses offer some opportunity to bring to the attention of students those personal qualities that improve one's probability to make good in teaching and those that limit his chances for success. Individual counseling by faculty members can also be helpful to students. Graduate schools are not likely to offer many special opportunities for personality development, but students can be encouraged to take such as may be available, even though they may be outside the usual academic program. Certainly, prospective teachers would profit from frequent exercise in public speaking.

It need scarcely be said that graduate students with personality traits that are a serious handicap to successful teaching should be discouraged from entering this particular occupation.

In conclusion may I point out that the progress of the pharmaceutical profession depends very largely upon its teachers? The creative work of great teachers is essential to this as to all other professions. They are its embodiment; they represent its aims and motives, its knowledge and skill. In general, they are looked to as symbolizing the best the profession has to offer; they are chosen to set forth to young people the things for which it stands. Through the teachers the future practitioners have their first intimate and extensive contact with the profession. The teachers determine what these young men and women will learn, what professional attitudes they will develop, what ideals of service they will espouse.

The position which the teachers of a profession hold suggests that no effort should be spared in recruiting the right persons and making them fully competent for their important work.

References

(1) Kelly, Fred J., Toward Better College Teaching, U. S. Office of Educ. Bull., 1950, No. 13, p. 18.
(2) Ibid., p. 22.
(3) Ibid., p. 6.
(4) Blegen, Theodore C., and Cooper, Russell M., (eds.) The Preparation of College Teachers, Washington, D. C.: American Council on Education, 1949, p. 79.

OBJECTIVES OF INSTRUCTION IN CHEMISTRY

in the Pharmaceutical Curriculum

The following statements of objectives of instruction in the courses in chemistry suggested for the pharmaceutical curriculum have been taken from the forthcoming report on The Pharmaceutical Curriculum by Lloyd E. Blauch and George L. Webster to be published in August by the American Council on Education. The figures in parentheses indicate the suggested semester hours of credit for the courses.

General Chemistry and Qualitative Analysis (10)

The particular objectives of this field of study, stated in terms of what the student should acquire, are: (1) knowledge of the properties of matter and the laws governing the transformation of matter and energy; (2) ability to observe and interpret experimental data; appreciation of the scientific method; (3) ability to use the language of science, particularly chemical terminology and notation; and (4) basic knowledge and skill employed in subsequent courses in pharmacy and chemistry.

Inorganic Pharmaceutical Chemistry (3)

The objectives of the course in inorganic pharmaceutical chemistry in the pharmaceutical curriculum are to acquire: (1) knowledge of sources, methods of manufacture, and industrial and pharmaceutical uses of inorganic chemicals; (2) familiarity with specific chemicals and tests for their identity and purity; (3) familiarity with characterizations -- official or unofficial -- such as solubility, crystalline form, color, odor, taste, and stability of inorganic chemicals; (4) familiarity with precautions for safe handling and use of inorganic chemicals; and (5) knowledge of pharmaceutical preparations of inorganic chemicals, their manner of preparation, qualitative and quantitative requirements, and uses.

Organic Chemistry (10)

The objectives of instruction in organic chemistry in the education of the pharmacist are: (1) acquaintance with accepted principles of nomenclature, and with the structure, occurrence, general and characteristic class reactions, properties of organic compounds, methods of synthesis, and fundamental theories of organic chemistry; (2) acquaintance with the skills and techniques of the organic laboratory, many of which are used without modification in pharmaceutical practice; and (3) acquaintance with the properties which affect the stability and compatibility of organic drugs and determine the suitable conditions for their storage, preservation, and use.

Quantitative Analytical Chemistry (4)

The objectives of instruction in quantitative analysis in the pharmaceutical curriculum are: (1) acquaintance with the language of quantitative analytical chemistry so that the student may be able to interpret and follow the directions of official assay procedures; (2) fundamental understanding of such topics as pH, indicators, adsorption, and chemical calculations which are of significance in the practice of pharmacy; and (3) introduction to and appreciation of precision techniques, experimental accuracy, and dependability and limitations of apparatus and method.

Physical Chemistry (6)

The student should obtain the following from the course in physical chemistry: (1) appreciation of the convergent nature of the basic principles of physics and chemistry; (2) appreciation of the value and importance of fundamental theory in explaining and predicting the behavior of particular systems; (3) knowledge of the method of describing chemical systems mathematically; (4) increased familiarity with the behavior of systems composed of gases, liquids, solids, and solutions; (5) a scientific basis for understanding processes which may have been carried out in the past empirically or are to be carried out in future courses and in practice such as: (a) solution, distillation, evaporation, sublimation, crystallization, extraction, pepitization, emulsification, colloid precipitation and stabilization; (b) determination of molecular weights, vapor pressure, melting points, freezing points, eutectic points, boiling points, solubility, pH, oxidation-reduction potentials, buffer capacity, distribution constant, surface tension, viscosity, rates of reaction, and isoelectric point; (6) knowledge of the methodology and instruments used in making physical measurements on chemical systems; (7) a scientific basis for understanding the chemical reactions which are studied in biological chemistry, physiology, and pharmacology; (8) knowledge upon which to base future development of new or improved dosage forms, more efficient utilization of medication, and more efficient manufacturing processes.

Biochemistry (6)

The student should obtain from the course in biochemistry: (1) understanding of the application of fundamental concepts to life processes (normal and pathological); (2) knowledge of the composition and

interrelationships of carbohydrates, proteins, and lipids, and the role of enzymes, hormones, vitamins, and minerals in the life processes (normal and pathological); (3) ability to interpret the pharmacodynamic action of drugs in terms of chemical principles; (4) knowledge of the principles and techniques of determining the metabolic fate of foods and the absorption, metabolic fate, and excretion of drugs.

Chemistry and Pharmacy of Medicinals (6)

The student should acquire from the course the following: (1) understanding of the chemical structure, pharmacological action, and pharmaceutical use of medicinals, and the effect of modifications of structure (isomerism, homology, analogy, isoterism) upon their physical, chemical, and pharmacological properties; (2) appreciation of future possibilities of new and as yet unforeseen developments in the field of medicinals in the light of past experience; (3) ability to read and interpret the nomenclature of new medicinal agents and to evaluate the therapeutic claims of competing products; (4) ability to recognize potential incompatibilities when two or more medicinal agents (official drugs, proprietaries, specialties) are combined, and ability to suggest ways of avoiding such incompatibilities.

Drug Assay (4)

As a result of the course in drug assay, the student should achieve: (1) greater familiarity with a wider variety of quantitative procedures; (2) familiarity with the problems of quantitative separation of pure principles from mixtures; (3) knowledge of the changes taking place in manufacturing processes which affect the quantitative composition of dosage forms; (4) knowledge of the changes taking place during storage which affect the quantitative composition of some preparations; (5) knowledge of legal limits of variation between label and quantitative composition; (6) knowledge of methods of sampling applicable to drug assay; (7) additional skill in the use of analytical instruments.

THE INTRODUCTORY COURSE IN CHEMISTRY

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Seventeen slides were used to present the material. This abstract consists of a brief description of each of the slides. The legend "Reprints available" following the slide number indicates that the material shown in the slide was taken from a journal article, reprints of which the author can supply upon request directed to him at the University of Iowa. The material in slides bearing the legend "No reprints" is reproduced in this abstract in cases where reproduction by typewriter is practical.

Slide 1. (No reprints) Subjects discussed in this paper.

1. Semimicro Laboratory Work
2. The Human Element
3. What About High-School Chemistry
4. Subject Matter

SUBJECT 1. SEMIMICRO LABORATORY WORK

This subject consists of two parts.

a) A non-H_2S scheme of qualitative analysis
b) Semimicro experiments in general chemistry

Slide 2. (Reprints available) From Cornog, Jr. Chem. Ed., 15, 420 (1938). Flow sheet non-H_2S group separations.

Slides 3 and 4. (No reprints) The proposed non-H_2S scheme requires only about half as many reagents and half as many pieces of student desk equipment as do conventional schemes.

Slide 5. (No reprints) Semimicro Laboratory Manuals for General Chemistry.

Burrows, Arthur and Smith — Macmillan
Semimicro Laboratory Exercises in General Chemistry

Gray, Latimer and Powell — Macmillan
A Course in General Chemistry. Semimicro Alternative

Cornog — Ginn
Semimicro Experiments in General Chemistry

King — Prentice-Hall
Semimicro Experiments in General Chemistry

Slides 6, 7, 8, 9. (No reprints). These are a series of pictures indicating that SM apparatus requires less storage space than does conventional apparatus.

Big Wt. = 12 lbs. Cost $15.00
SM Wt. = 5 1/2 lbs. Cost $6.20

Slide 10. (No reprints)
Advantages and Disadvantages of SM in General Chemistry

Advantages

1. Permits more accurate quantitative experiments
2. Eliminates fume nuisance
3. Saves locker space
4. Avoids midyear change-over

Disadvantages

1. Initial loss in discarding big apparatus
2. A few classical experiments are impractical (glowing splint in 0_2 etc.)

Summary. Semimicro apparatus may be used with advantage both in general chemistry and qualitative analysis without loss in instructional value and with substantial savings in cost and locker space requirement.

SUBJECT 2. THE HUMAN ELEMENT

Slide 11. (No reprints). The graphs shown in this slide indicate that scores made by college freshmen on the Army-alpha general intelligence test were very much higher than the scores made by 50,000 white, literate army draftees.

Implications. 1. College students are a highly selected group, potentially useful to society. Our job is to make them so.

2. With increasing college enrollments, the average mentality of the college group will approach that of the general population. Fitness for college work decreases with increasing college enrollment.

Slide 12. (Reprints available). From Cornog and Bartow, Ind. & Eng. Chem., 15, 301 (1923). Intelligence Test Scores vs. Final Grades in Freshman Chemistry.

Implication. General intelligence and allied tests, given at the beginning of the introductory course, accurately forecast the performance of students making high and low scores, but are of little use in predicting the performance of students making intermediate scores.

Slide 13. (Reprints available). From Cornog, Jr. Chem. Ed., 6, 85, (1929)

Types of examination questions frequently answered correctly and those frequently answered incorrectly.

Answers by 529 freshmen who had had high-school but not college chemistry. Case, Kansas State, Minnesota, Montana State, North Carolina, and Rutgers co-operating.

Per cent correct

Example 1

Complete and balance KOH + HCl = 69.0
Right 356 wrong 44 omitted 120

Example 2

Complete and balance $Al(OH)_3$ + H_2SO_4 = 16.8
Right 89 wrong 187 omitted 253

Example 3

If 7 g of iron unites with 4 g of sulfur, how many g of iron sulfide is formed? 68.6

Right 363 wrong 57 omitted 109

Example 4

The atomic weight of H = 1 Cl = 35.5 Zn = 65

What weight of Zn will be needed to generate 10 g of H_2 using dilute HCl? 16.8

Right 89 wrong 114 omitted 326

From Jr. Chem. Ed. 6, 85 (1929)

Comment. The ability to grasp ideas or to solve problems declines rapidly as the number of parts or factors increases.

SUBJECT 3. WHAT ABOUT HIGH-SCHOOL CHEMISTRY

Slide 14. (Reprints available) From Cornog, Jr. Chem. Ed., 6, 85 (1929)

Chemistry training test scores indicate that students with one year of high-school chemistry know about as much chemistry as those who have had college freshman chemistry.

Comment on what to do with freshmen who have had high-school chemistry.

First. Segregate and give them a stepped-up or modified standard freshman course. No particular merit in this plan.

Second. Segregate those making high training test scores in one group, hereafter name the "high group" and those making low scores into a "low group". Put the low group with those who have never had chemistry. Give the high group qualitative analysis (second semester chemistry) in the first semester, and quantitative or organic chemistry in the second semester.

Experience has shown that the "high group" plan just mentioned is entirely feasible from an instructional viewpoint but meets trouble on the administrative side. Premedics must have one year of inorganic, etc. At Iowa, freshmen with high-school chemistry have the option of electing the "high group" plan, with only an occasional student choosing it. Most students wish to "fatten" their grade point averages by taking the regular course along with those without high-school chemistry.

SUBJECT 4. SUBJECT MATTER

Slide 15. (No Reprints) A Comparison of the Number of Words in Different Texts
McGregory (1902) 106,000 words
Pauling (1950) 355,000 words
Babor and Lehrman (1950) 371,000 words
Smith and Ehret (1946) 531,000 words
Briscoe (1949) 608,000 words
Sears, Roebuck Catalog (1952) 900,000 words
Implication. The quantity of subject matter in many modern texts is so large that it cannot be covered consecutively within the time scheduled for most beginning chemistry courses. On the other hand, continuity is lost if the instructor tries to use selected parts of such texts.

Slide 16. (No reprints) From Cornog and Colbert., Jr. Chem. Ed., 1, 6 (1924).

An analysis of several thousand questions given in final examinations used in twenty-two typical American colleges and universities showed that about two-thirds (55.7%) of the questions were "theory" and one-third (44.3%) of the questions dealt with descriptive material.

A similar analysis of the subject matter in three widely used texts showed that the content of texts was about one-third (29.5%) theory and two-thirds (70.5%) descriptive matter.

Implication. In actual practice, theory is the backbone of most courses in introductory chemistry.

Slide 17. (No reprints). Three pertinent quotations.

C. W. Foulk, Ohio State University

"You can read any book in any language if you know what the words mean."

A. O. Smith, University of Oregon

"I should think that one of the main objectives in teaching freshman chemistry, or for that matter any other subject, would be to have the student know something about the subject when he had finished the course."

P. R. Bunch, Harvard University

"The capacity of the mind to grasp the subject matter of a lecture, is limited by the endurance of the sitter."

Conclusion. Try to do a thorough job and don't expect too much.

SCREENING OF STUDENTS FOR THE INTRODUCTORY COURSES IN CHEMISTRY

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In every college course there must be a certain measure of homogeneity in the maturity, background of information, and skills of the class as a whole. The almost universal method of ensuring this homogeneity in advanced courses is the requirement of certain prior courses as prerequisites. For introductory courses this simple and effective scheme cannot be used.

For admission to the introductory course in chemistry there is one universal requirement -- the student must have satisfied the entrance requirements of the college. Among different institutions this standard may vary all the way from showing the diploma of any high school to the demonstration of ability on a battery of tests of aptitude and knowledge of specific fields of subject matter. Beyond entrance requirements there may be the further requirement of passing certain courses in high school such as chemistry or algebra. A still higher hurdle is the demonstration of competence by the use of one or more placement or aptitude tests where these have not been a part of the entrance requirements. This paper is concerned mainly with the use of placement tests for steering students into the most appropriate of two or more introductory courses in chemistry.

The use of a placement test requires a small expenditure of money and a considerable expenditure of time at one of the busiest periods of the academic year. We must first raise the question: does the information obtained have sufficient practical value to warrant giving the test? At colleges where all students are given the same introductory course no placement test is necessary. This is the case in many smaller colleges and in some of the large ones, such as the University of California. But a large number of institutions offer two or more introductory courses of different character for students with different degrees of preparation. A common pattern is one course for students who have studied chemistry in high school and another for those who have not. Then some colleges have a separate course for students of high ability with whom the work can be covered more rapidly and more topics introduced.

The separation of students on the basis of credit in high-school chemistry or the lack of it is far from satisfactory. Early in the term it is apparent that many students in the course requiring high-school chemistry are not able to keep up with the rest of the class. A study (1) of the relation between grades in high-school subjects and first semester university grades made in the same subjects showed correlation coefficients of 0.35 to 0.40 for English, mathematics, foreign languages, and history, whereas for chemistry the coefficient was 0.29. None of these coefficients indicates a very high correlation, but in chemistry it is significantly lower than in other subjects. One of the main reasons for this lower correlation in chemistry is the fact that in many high-school courses there is little or no attention paid to the quantitative relations and numerical problems of chemistry whereas in college this aspect is given much more emphasis. Thus high-school chemistry, as often taught, and college chemistry call for considerably different skills and thus are like different subjects. The emphasis in English, mathematics, social studies, and foreign languages is much more similar in high school and college.

At the University of Michigan the need for a placement test arose in the courses in general chemistry for engineers. Some time ago, students with no high-school chemistry were required to take one year in college (eight semester-hours), whereas those with entrance credit in chemistry were required to take only one semester, a five-hour course. The theory was that a student with a background of high-school chemistry should be able to attain in one semester the same proficiency as a student without high-school chemistry attained in one year. For a majority of the class this worked out satisfactorily, but the poorer students in the one-semester course were unable to maintain the pace, and failures in the course ran from 10 per cent to 15 per cent, which was about three times the rate of failure in most other courses taken by freshman engineers. This was clearly unfair to students who were admitted to this course under the tacit assumption that they had as good a chance of doing satisfactory work as in other courses of the freshman year. We felt that we could not lower the passing grade because the one-semester course satisfied the prerequisites for qualitative analysis, and we were certain that the poorer students were headed for almost certain failure in this more advanced course. We felt that what was needed was a more reliable basis for selecting the students for the one-semester course, and a placement test was the most promising device to try.

For the first few years we used the Iowa placement test in high-school chemistry; in recent years we have been using the test on high-school chemistry

of the Cooperative Test Service of the American Council on Education. We ordinarily allow about the top four-fifths of the group taking the test to enroll in the rapid one-semester course, and require the bottom fifth to take the slower and easier two-semester course. Since adopting this method of selecting students our percentage of failures has dropped to a more normal figure, and we are told that students from the one-semester course do no worse in qualitative analysis than students from the two-semester course. We feel, then, that for this particular situation the placement test is distinctly worth while. As for the mechanics of administering the test, it is given to all freshman engineers who have studied chemistry as one of the events of their orientation program. In recent years it has been scheduled at eight o'clock on Tuesday evening, and the lists of students accepted for the one-semester course have to be ready for the beginning of registration the next morning. The actual writing time for the test is 45 minutes; the 76 questions and problems are all of the multiple-choice type. We are able to obtain a group of 20 to 30 of our graduate teaching fellows to aid in proctoring and scoring the test. With the aid of scoring keys a person can grade about 20 papers an hour. We have had as many as 600 papers to score in an evening and have always been able to complete the scoring in less than an hour and a half; then it requires another hour to prepare the lists of accepted students. Although this test is available in a form adaptable to scoring by machine, we are able with our large group of assistants to beat any machine in existence.

More than the past twenty years we have accumulated a large number of records bearing on the effectiveness of this test as a basis for selecting students for the one-semester course. I shall present a few representative samples of the studies we have made. To measure the effectiveness of the placement test for the specific problem of picking out in advance the people who are headed for failure, we should have used the test for a year or two when all students with high-school credit in chemistry were allowed to take the course and observed the correlation between score in the placement test and failure in the course. But this was never done. We can study the grades made by the students not accepted for the one-semester course in the first semester of the one-year course which they are required to take. There were 58 such students in the fall semester of 1951-52. Table I shows the grades (in per cent) earned in Chemistry 3 by these students.

A grade of D is unsatisfactory and unless the student has an average of C or better for the semester he has to repeat all courses in which his grade was D. We see, then, that one-third of the students not accepted for the one-semester course made unsatisfactory grades in the easier course. It is certain that these same students would have made

TABLE I

	A	B	C	D	E
Grades made by students not admitted to the one-semester course (Chem. 5E)	3	21	43	27	5
Grades of all 407 students in class	12	23	43	17	5

unsatisfactory grades in the more difficult course. How many more would have made unsatisfactory grades is a matter of conjecture. I believe that another third of the group, or about twenty students, would have made unsatisfactory grades if they had been allowed to go on in the more difficult course. This is the real measure of the value of using the test. There will be differences of opinion as to whether the considerable amount of labor involved is justified by saving twenty students from getting an unsatisfactory grade by steering them into a course better suited to their ability; I am inclined to believe it is worth while. It can also be observed that some of the students who were required to take the easier two-semester course could have passed the one semester-course if they had been allowed to take it. Those of us who have enthusiasm for the educational values of a course in general chemistry will not admit, however, that it is any hardship to substitute for a superficial one-semester course which the student can barely pass a slower and more thorough course which gives him a much better grasp of the subject.

Another comparison of interest is the correlation between final course grades and scores on the placement test. For this study we can take the 132 students who were accepted for the one-semester course and who received final grades in the course. For this comparison, the students who completed the course will be placed in three groups: (1) those receiving grades of A and B (good to excellent), (2) those receiving a grade of C (average), and (3) those receiving grades of D and E (unsatisfactory) along with those who transferred back to the two-semester course because they found they could not keep up with the one-semester course. Placement test scores for these students will also be arranged in three groups arbitrarily designated as (1) A-B, the highest 35 per cent of scores in this group, (2) C, the next 45 per cent of scores, and (3) D-E, the lowest 20 per cent of scores in the group. These percentage distributions approximate the percentages of the different grades in many university courses. Note that these percentages are based on the group which was permitted to enter the one-semester course and do not include the lowest scores in the group which was not permitted to enroll in the course. Grades in the course will be expressed as the percentage of the given group in the placement test making the designated grade in the course. Thus in Table II there were 47 students whose scores

Table II

Grade in Chem. 5E	A-B	8	27	30	25
	C	43	37	52	48
	D-E or drop back	48	36	17	27
Score in placem't test		D-E	C	A-B	Entire course
No. in each group		(25)	(60)	(47)	(132)

on the placement test were in the A-B group; of these 47 students, 30 per cent made a grade of A-B in the course, 52 per cent a grade of C, and 17 per cent a grade of D-E.

This table shows a fair correlation between score in the placement test and grade in the course. The correlation could undoubtedly be improved if a longer test were used; the student writes for only 45 minutes. Also a better correlation would be obtained if some correction were applied for the time that has elapsed since the student studied chemistry; we make no allowance for this variation. Furthermore, multiple correlations with scores on mathematics tests and possibly others would undoubtedly give more reliable results. We feel that we can not devote more time to this task than the 45 minutes of writing asked of the students and not more than four hours of work from the group of about twenty assistants. Under these limitations we feel that the information is sufficiently reliable to warrant continuing the program. We must remember that some of the causes of failure in a course come from causes that arise during the semester and can never be foretold by any test made at the start of the term.

Several studies have been reported from other institutions. At the University of Pittsburgh correlations were calculated between scores in their mathematics placement test and grades in the first course in chemistry (2). The grades in chemistry and mean scores in the mathematics placement test are related as follows: A or B (35.3), C (30.7), D or F (27.0). The opinion is expressed that this correlation is sufficient to warrant use of the mathematics placement test as a basis for admission to the more difficult of two courses rather than credit or lack of it in high school chemistry. At the University of Pennsylvania (3) studies were made on the correlation between grades in the first course in chemistry and scores on the Scholastic Aptitude Test of the College Entrance Examination Board. One of their several tables will be selected and modified to be comparable with our Table II. This table gives the correlation between grades in the first course in chemistry and scores on the mathematical section of the aptitude test. Their basis for grading is not the same as ours, but if we group their data into three groups:- (A-B-C), (D-E), and F, they will approximate the three groups used in Table II. This regrouping leads to Table III below, in which the figures have the same significance as in Table II.

Table III

Grade in Chem. 101 (U. of Penna.)	A-B-C	3	21	51
	D-E	32	45	39
	F	65	34	10
Mathematics Score in Scholastic Aptitude Test		0 to 472.5	472.5 to 592.5	592.5 to 800.0
Number in each group		(72)	(230)	(181)

The correlations shown in this table are not greatly different from those in Table II between grades in the first course in chemistry and scores in the placement test in chemistry; the correlation in the mathematics aptitude test appears to be somewhat the better of the two. Teachers in elementary chemistry will not be surprised at this.

In addition to using the placement test for weeding out students not adequately prepared for the rapid and more difficult course for engineers, we have used it also to select a small group of students with excellent preparation in high-school chemistry who have been permitted, if they so wished, to skip the first semester of our one-year course. The wide range of preparation and of ability shown by the students of a class always presents a problem to the teacher. The educational maxim that each student should be kept at his highest level of achievement cannot always be followed to its full effect in a large class. The quantity and quality of work that can be done by the best students is far in excess of the capacities of the poorer students. There are various devices that can be used in a large class to proportion the work to the capacity of the students, but any possible scheme for eliminating the very best and the very worst students in a class group should be put into practice.

Our rapid one-semester course is offered only to students in the College of Engineering. Students in the Colleges of Literature, Science, and the Arts, Pharmacy, and others take the two-semester course. The placement test is not given to all students planning to elect this two-semester course; but any student who thinks he has good preparation in chemistry and who would like to advance more rapidly may take the test, and if he shows excellent ability he is allowed to skip the first semester of the one-year course and start with the second semester's work. Ordinarily, about a fifth of the students who choose to take the test are admitted to the second half of the course. This group always does much better work than the average of the class whose preparation has been the first semester of the college course. Records of 45 students in the years 1943 to 1945 who started directly on the second semester's work after their high-school course are shown in per cent in Table IV:

TABLE IV

Grades in Chem. 4	A or B (60)	C (33)	D or E (7)

These figures would indicate that we could have lowered our selection score somewhat and still had a group who would have done better than the average of the course. It speaks well for the reliability of the test that the students selected for admission to the more advanced course can make such a good record in competition with students who have had one semester of college chemistry. These figures also tell us that we receive a few students from high school whose background and ability in chemistry are truly excellent. The proportion, of course, is small; the number of students permitted to skip the first course amounts to only about 3 per cent of the enrollment of the course; we could probably raise the proportion to about 5 per cent with reasonably good results.

Table V shows the comparison of grades earned in the first course and scores in the placement test for students who took the test in an attempt to skip the first course but were not considered good enough for admission to the second course. This is a somewhat select group, because students usually do not take the test unless they think they have had a good record in their high-school chemistry. As in the previous tables, the three groups of scores in the placement test are based on the approximate arbitrary percentages A-B 35%, C 45%, and D-E 20% of the students in the particular group for which this comparison is being made.

TABLE V

Grade in Chem. 3	A-B	19	45	83	35
	C	45	45	15	45
	D-E	36	10	2	20

Score in placement test	D-E	C	A-B	Entire Course
Number in each group	(31)	(80)	(52)	(approx.)

The correlations between scores in the placement test and grades in Chem. 3 as shown in Table V may be compared with the somewhat similar comparison of grades in Chem. 5E, the one-semester course for engineers, shown in Table II. The correlations are somewhat different, but it must be remembered that for the group represented in Table II, practically every student who had studied chemistry in high school took the placement test, whereas for the group represented in Table V only students who felt they had good high-school preparation took the test. Thus, the low-ranking D-E group on the placement test in Table II had considerably lower scores on the test than did the low-ranking group of the students shown in Table V.

This is an attempt to describe our experience with placement tests for the purpose of obtaining a more homogeneous group of students in two different types of courses. The typical statistical distribution curve has a toe and a heel representing a small number of exceptionally high values in the toe and of exceptionally low values in the heel. Where these values are scholastic ability of the students in a class, we find that the cases represented by the heel act as a drag on the work of the class as a whole. The cases represented by the toe of the curve are individuals whose abilities would permit work of much higher quality and quantity than the average of the class; these individuals are required to work considerably below their capacities and often develop habits of laziness. In the difficult one-semester course for engineers we believe that the placement test is a reasonably reliable method for cutting off the heel and placing these students in a course better adapted to their abilities and preparation. The toe of the curve in this group does not worry us because the course covers so much ground and does it so rapidly that it is a challenge to the best of the students. The other application of the test is for the purpose of cutting off the toe of the curve in the first part of the two-semester course. For this purpose we have found the placement test a remarkably accurate tool. There is also a heel to the curve in this course, and it would undoubtedly save a certain number of cases of failure with their attendant heartaches and adverse effects on personality if the students represented by the heel of the curve could be selected before the start of the course and placed in the course designed for people with no previous study of chemistry in high school. The only reason we have not done this is the amount of labor involved. As it is, we ask only those students who think they have a good preparation to appear for the placement test. If we asked all students planning to take Chemistry 3 to appear for the test, we should have to handle some 5,000 more papers, and under our present program, instead of finishing the task at midnight, it would be nearer to sunrise.

There is another possible field of usefulness for the placement test with which I have no experience. That is in sectioning classes on the basis of ability. This is another method of obtaining greater homogeneity of smaller sections and of proportioning the quantity and quality of the work in a large course to the capacities of the students. There are very good arguments for this plan which have been well stated by the late Dean Seashore of Iowa State University and by others; there are also arguments against it. I believe it is used at the University of California for their beginning course in chemistry. In a large

course it can be handled by having two or three simultaneous sections of different levels of ability meeting at every class hour used, so that students can be shifted from one section to another during the term without disrupting their schedules. For smaller courses, or where there is a limited number of classrooms, and also in laboratory sections where shifting of sections may involve troublesome transfers of desk apparatus, the use of a placement test before classification in sections would give a reasonably good distribution according to abilities.

This gives a summary of our experience at Michigan with the use of placement tests as a device for improving instruction by obtaining more homogeneous classes and by steering students before registration into courses best suited to their capacities.

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A DECADE OF DEVOTION

W. Paul Briggs

Executive Director, American Foundation for Pharmaceutical Education

During an earlier time of economic and political uncertainty, Henry Ford was asked if he thought conditions would return to normal. In reply he asked, "What is normal?" The creator of mass production of automobiles said, "Walking is normal, but I do not think man will ever walk again if he can ride in a car."

Today we are asking each other if world conditions in general, and the practice of pharmacy in particular, will ever return to normal. From the pharmaceutical viewpoint, a desire to return to normal would amount to the admission that pharmacy and the health sciences are static. Because pharmacy is a dynamic force, constantly advancing its contributions to the public welfare, one can hardly define "normal," much less expect to live it. I am sure that the "good old days of pharmacy," when we brewed infusions, spread plasters, and rolled pills, are longed for by some only because distance lends enchantment to the view. In truth, those days were never very good for pharmacists or the public, and much of the medication dispensed, while harmless, was often helpless as well.

These teachers' seminars, willingly supported by the American Foundation for Pharmaceutical Education, reflect your farsighted understanding of the continuously advancing frontiers of pharmaceutical and medical science. Strategic retreats sometimes are accepted practices in warfare, but in our war against human ills all movements must be forward. As teachers of the pharmacists of the future, you have been the first to recognize the necessity of keeping yourselves abreast of the almost hourly developments in our professional and allied scientific fields. Your devotion to constant self-development is pharmacy's guarantee for the competence of tomorrow's practitioners.

Your devotion to the preparation of thoroughly qualified pharmacists for their indispensable services on the health sciences team is, in a sense, comparable to the Foundation's devotion to pharmaceutical education. Neither seeks self-glorification or rewards. Both seek only to serve others to the end that pharmacy and the public may enjoy the benefits of knowledge and embrace every possible opportunity for progress beyond the nostalgically romantic comforts of the normalcy of the past.

The American Foundation for Pharmaceutical Education is the outgrowth of a nebulous idea first voiced nearly twenty years ago in meetings of the National Drug Trade Conference. At these meetings, many leaders in education and in the industry urged the formation of an agency, representing as does the Conference itself, all elements of the profession, trade, and industry of pharmacy, to aid pharmaceutical education. The first formal step in this direction occurred in 1939, and three years later, with the unanimous endorsement of the National Drug Trade Conference, the American Foundation for Pharmaceutical Education was incorporated.

The members of the Foundation are: American Association of Colleges of Pharmacy, American Drug Manufacturers' Association, American Pharmaceutical Association, American Pharmaceutical Manufacturers' Association, Federal Wholesale Druggists' Association, National Association of Boards of Pharmacy, National Association of Chain Drug Stores, National Association of Retail Druggists, National Wholesale Druggists' Association, and The Proprietary Association. These same organizations are the members of the National Drug Trade Conference; the Foundation and the Conference are the only bodies which formally represent every segment of the essential profession of pharmacy and the great drug trade and industry.

The Foundation is governed by representatives from these ten associations and twenty-eight elected directors from every branch of pharmacy (including five from the A.A.C.P.). The Board of Directors is truly devoted to the purposes of the Foundation, which, as stated in the Articles of Incorporation, are "exclusively scientific and educational." Among the activities of the Foundation are the financing of the Pharmaceutical Survey; these annual seminars for pharmacy teachers; undergraduate scholarships; graduate fellowships, and the newly established teaching fellowships in business administration; and substantial support to the American Journal of Pharmaceutical Education and the American Council on Pharmaceutical Education.

Over the past decade the Foundation has provided 269 graduate fellowships and is currently supporting 99 fellows and teaching fellows. Nearly 100 Foundation-supported fellows are today serving on the faculties of our colleges of pharmacy, and approximately 50 are filling important posts in the drug industry. Our graduate fellowship program was not started until 1946, but its worth-while accomplishments to date, and its promise for the future, mark it as one of the major activities of the Foundation.

The Foundation has provided undergraduate scholarship funds to colleges of pharmacy, which have

aided 981 students to prepare for service in the profession. During the war years, the Foundation financed an effective program to interest young people in careers in pharmacy and, in part, the number of applicants to our colleges today is due to this farsighted plan.

At the urgent request of your American Association of Colleges of Pharmacy, the Foundation supplied funds to make possible The Pharmaceutical Survey. This exhaustive study of pharmacy, conducted by the American Council on Education at a cost of nearly $200,000, did much to stimulate all phases of pharmacy and particularly to point the way for pharmaceutical education. One by-product of the Survey is the Teachers' Seminar program. Started in 1949, these seminars give promise of rapidly improving and modernizing training in pharmacy. I hope these will be continued, not only to cover all of the disciplines of pharmacy, but possibly extended into the area of teaching methods and techniques.

While the American Council on Pharmaceutical Education made significant contributions to the advancement of pharmaceutical education, it was always greatly handicapped by lack of funds to carry out its programs most effectively. Again, partly as a result of the revelations of the Survey, the Foundation began, in 1946, to support the Council to a great extent so that its work could be placed on a firm and continuing basis. The truly impressive developments in our colleges in the last few years can be traced, in large measure, to the stimulation and constructive guidance of the Council -- assistance made possible by the Foundation.

These and other activities of the American Foundation for Pharmaceutical Education represent contributions by industry and an expenditure by the Foundation of close to two million dollars. You have wisely used this support to seek the highest possible level for pharmaceutical education. But you need more help from the Foundation, and we believe you will get it. The Foundation is an all-drug enterprise, and its recognition and support is increasing at an encouraging rate. To the best of my knowledge, pharmacy is the only field in which is found the enlightened interest and generous support of the manufacturing and distributing segments for the retail and professional level and the educational system. The devotion of the American Foundation for Pharmaceutical Education to your indispensable work is a reflection of the devotion of the trade and industry of pharmacy to the profession. As that interest and support increases over the years ahead, so will the Foundation's help to pharmaceutical education increase.

While the Foundation has done much to support your splendid work in the past, it is neither basking in self-righteous satisfaction nor complacent about your future calls upon it. Daily we note, with deep appreciation, a renewal of interest by industry in the work of the Foundation, and there is abundant evidence that the Foundation will be ready to strengthen your own efforts to advance pharmaceutical education in the future.

Even a casual review of the program for this Seminar indicates such breadth of treatment of the subject of pharmaceutical chemistry that, even if qualified, I could not add anything of a technical or pedagogical nature. But there is one aspect of graduate training in pharmaceutical chemistry that I beg leave to comment upon.

Let me introduce my comments by emphasizing that they are not statements of personal opinion or judgment of the Foundation. Neither presumes nor desires to ever infringe upon academic freedom or even to suggest training patterns to those who are qualified, indeed consecrated, to teaching. What I have to say must be received entirely as a relay of the views of others.

In brief, I give you two provocative comments that have come to me from enough sources, and with such frequency, that I believe I should bring the matter to your attention. Both can be stated as questions. First, "Precisely what is a pharmaceutical chemist in light of today's ultraspecialization, and where does such a man fit into the research and development programs of the drug industry?"

Second, "Why do not more colleges offer graduate training in pharmacy as such?" You will note that these questions deal entirely with industrial utilization, not with teachers, or the training of teachers, of pharmaceutical chemistry for our colleges of pharmacy.

Neither question is altogether new to you. Possibly, this is entirely a matter of nomenclature, but if so, I think you would be well advised to clarify these uncertainties. If you will check the organization charts of a few pharmaceutical manufacturers, you will seldom find a separate division of pharmaceutical chemistry, and this may explain the origin of these questions. To be sure, many men that you have trained in pharmaceutical chemistry are today serving in the laboratories of industry. But most often their office or laboratory bears a more specific title than pharmaceutical chemistry. Possibly our standard title, pharmaceutical chemistry, now needs to be qualified to show exact areas of specialization within that field.

The other side of the problem is the impression of some in industry that, for example, a researcher in organic chemistry can best be trained in a department of chemistry, rather than by a school of pharmacy or jointly by a school of pharmacy and a university department of chemistry. You and I know that, in many instances, a pharmacy graduate student may receive more, and sometimes better, training in organic chemistry than does a chemistry major. While this fact is comforting, it is not always readily recognized by personnel and scientific directors. I have mentioned a problem, but I have no solutions to offer, and actually I should not attempt to do so. But I hope the matter

will warrant your study because I believe it important to clarify these misconceptions.

While the Foundation is not an employment center, we have noted that the industry and the colleges seem to be more actively seeking men with graduate training in pharmacy than in any of our other specialized fields. Perhaps some of the current demand for research and development men in pharmacy stems from the failure of industry, until recently, to recognize the place for pure pharmacy on the technical staff. Or it may arise because some Ph.D.'s in pharmaceutical chemistry, while qualified in pharmacy, are not identifiable as such by the label of pharmaceutical chemist. Of course, the thesis title and area of graduate research will often pinpoint the special field of any Ph.D., but this is a somewhat indirect means of identification. Incidentally, while we could not do it for the 1952 Revision of the Roster of American Foundation for Pharmaceutical Education Fellows, we hope to include the thesis for all fellows in the 1953 Revision of the Roster.

I know that some of you are primarily specialists in pharmacy with an interest in and advanced training in chemistry; others are primarily specialists in chemistry with an interest in and advanced training in pharmacy. Maybe we are merely confronted with the old question of the difference between the chemistry of pharmacy and the pharmacy of chemistry. In any event, you are the ones qualified to consider the significance, if any, of the comments I have relayed to you. But, in my view, you have, in these questions, concepts which should not be ignored.

This Seminar provides the first opportunity since our Board of Grants meeting last month to announce that the Board awarded 21 new graduate fellowships and five new teaching fellowships in business administration for the academic year 1952-53. The Board also renewed 35 fellowships, and 38 others are currently in effect. This total of 99 fellowships and teaching fellowships is continuing evidence of the strength of the Foundation, and of its devotion of that strength to the vital development of pharmaceutical education in America.

This year the Foundation received 95 applications for graduate fellowships and teaching fellowships. Every applicant had been accepted by a graduate school, and the vast majority were really superior students. However, with our undergraduate scholarship program and support to the American Council on Pharmaceutical Education, to the American Journal of Pharmaceutical Education, and to these teachers' seminars, our available funds for graduate fellowships restricted the Board to 26 awards. While this number exceeds slightly the minimum recommendation of The Pharmaceutical Survey, we are aware of the steadily increasing need, in our schools and in the industry, for men with sound graduate training. The Foundation is moving forward, and we confidently expect that in the near future we can provide substantially more fellowships to meet these requirements of education and the industry.

It has been good to be with you. I am confident that these seminars will become an increasingly important influence in the advancement of teaching in pharmacy. On behalf of the officers, members and directors, I extend congratulations from the Foundation on the continuing progress of pharmaceutical education. Your accomplishments over the past decade have been noteworthy. We hope that the Foundation will play its full part in the further development of education for the profession of pharmacy during the next decade.

THE COURSE IN INORGANIC PHARMACEUTICAL CHEMISTRY

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A brief survey of the course titles and descriptions in the catalogues of the several colleges indicates that we teachers of pharmaceutical chemistry are possessed of a profound ingenuity and versatility at explication. The general subject matter which most of us would regard as inherent in a course called Inorganic Pharmaceutical Chemistry is described under a multitude of appellations such as: Inorganic Pharmacy, Inorganic Medicinal Products, Inorganic Pharmaceutical Products, Inorganic Medicinals, Inorganic Pharmaceuticals, Pharmacy of Medicinal Products, and Pharmacy and Chemistry of Medicinals. Infinite variations of these are made by juggling the word orders or by substitution of synonymous terms. Some variation must be expected in view of the fact that the course is sometimes offered in the department of pharmacy instead of the department of pharmaceutical chemistry. However, one is sorely tempted to quote the famous line from Shakespeare: ". . . a rose by any other name would smell as sweet."

The catalogue descriptions vary as widely as the titles, but my own succinct definition is "a study of the occurrence, methods of preparation, properties and uses of the inorganic chemicals encountered in pharmacy and medicine." This, admittedly, is a somewhat plagiarized version of the definition given in the report on "Physical Science and Mathematics in the Pharmaceutical Curriculum" of the Pharmaceutical Survey (1), but it does describe, in a nutshell, the general subject matter of the course.

Just what purpose is served by the inclusion of inorganic pharmaceutical chemistry in our curriculums? Does modern pharmaceutical practice justify its continuation? For some answers to these questions we may turn to the Pharmaceutical Survey and to several of the current prescription surveys. According to the previously mentioned report on physical science, "The course in inorganic pharmaceutical chemistry is designed to amplify and complement the descriptive information of general chemistry in order to develop an adequate basis for properly handling inorganic chemicals in prescription practice." I think that this statement of purpose is well made. It should, however, be enlarged to encompass the many inorganic chemicals handled and dispensed by the practicing pharmacist in ways other than in the compounding of prescriptions. From an economic standpoint the over-the-counter dispensing of chemicals is probably the more important. In this category would be included insecticides, herbicides, pesticides, veterinary products, fertilizers, household chemicals, etc.

The importance of this nonprescription group of compounds cannot be overemphasized. If one were to consider only those inorganic chemicals used in prescription work as indicated in current prescription surveys, the need for a course of this type in modern pharmaceutical curriculums would be slight indeed. For example, three recent surveys give the figures of 11.8 per cent (2), 10 per cent (3), and 7 per cent (4) of prescriptions filled as requiring compounding. Of the seventy-odd official compounds or preparations which are specifically listed among the most frequently prescribed items in one of these reports (4), roughly a dozen are inorganic chemicals. Further analysis shows that about one-third of the total prescriptions filled called for official items, so that less than 5 per cent of the total was for inorganic compounds. This does not include buffering agents and preservatives. Thus it is evident that the frequency with which the pharmacist encounters inorganic chemicals in prescription work is low. From this fact alone, however, pharmaceutical educators are not justified in relegating inorganic pharmaceutical chemistry to the limbo of "deadwood." Certainly the pharmacist must be prepared to compound any prescription even if it is one in a hundred. Also, a knowledge of the properties of various inorganic compounds is essential in the preparation of buffered and isotonic solutions, etc. In my opinion, the continued inclusion of such a course in our curriculums is amply justified, although decreased emphasis in this area is perhaps indicated by current trends. I shall say more about the time to be allotted to the course later in this paper.

What relationship does the course in inorganic pharmaceutical chemistry bear to the rest of the curriculum? At what point should it be offered? What should the prerequisites be? The curriculum flow sheet depicted in the 1949 report of the Committee on Curriculum of the A.A.C.P. (5), which precipitated so many interesting discussions at the Pharmacy Teachers' Seminar in Madison, has the course (as inorganic pharmacy) rather strategically located early in the professional program of study where it should be. Actually, the course might well be the first professional course taken by the student, other than perhaps orientation. Most colleges offer it in either the sophomore or junior year of the four-year program. The subject matter is definitely necessary background

material for the courses in operative pharmacy. If the student is to appreciate the compounding technics he is learning, he should know something about the substances with which he is working. Obviously then, it should precede operative pharmacy as a separate course and not merely as a part of the operative pharmacy series. It would seem immaterial whether the subject matter is presented by the pharmaceutical chemistry department or the pharmacy department as long as the instructor is qualified. I personally feel that the course should be approached from the chemical angle and that the pharmaceutical manipulations be reserved for operative pharmacy.

Instruction in inorganic pharmaceutical chemistry is also important as background material for the later discussion of pharmacology where a knowledge of the properties of inorganic compounds is necessary to proper understanding of pharmacological action. The course may also be linked to biochemistry. Certainly, an appreciation of enzymatic transformations involved in metabolism and of the role of minerals depends on a knowledge of the inorganic compounds involved.

This course also has value as a foundation for the later presentation of organic medicinal products. Pharmacognosy likewise draws upon the subject matter contained in inorganic pharmaceutical chemistry for the discussion of the nature of plant constituents, their occurrence, function in the plant, and possible biogenesis. The uses of plant drugs will also be better understood if the student has mastered the fundamentals of this course. As stated in the definition, the eventual direct application of the information gained here is found in the courses in dispensing. Thus it is obvious that inorganic pharmaceutical chemistry has a direct tie with all phases of the pharmaceutical curriculum.

As previously mentioned, the course amplifies and complements the descriptive information of general chemistry, and thus general chemistry must be prerequisite. Let me emphasize here that this general chemistry course should be no different from that taken by the engineers, premedical students, or others. In other words, I am categorically opposed to watered-down courses "for pharmacy students only," not only in chemistry but in any other area. In fact, it is my opinion that pharmacy students should be well "triturated" with the students of other colleges in these service courses and not be isolated in special sections. Such a policy of nonsegregation would do much to overcome the old antipathy that some chemistry and other departments hold for pharmacy students. Although this attitude has largely disappeared as pharmaceutical education has come of age, it still exists in a few institutions.

In most colleges the course in general chemistry includes qualitative analysis, but if a separate course in qualitative analysis is given, it should also be prerequisite to inorganic pharmaceutical chemistry. In some of these latter schools I believe that the material ordinarily included in inorganic pharmaceutical chemistry is covered in the qualitative course.

It is also desirable and important that college mathematics (algebra and trigonometry) form a part of the foundation material. Whatever special pharmaceutical calculations are necessary may be included in the pharmaceutical chemistry course so that the course in calculations, if offered by the college, need not precede it.

The method of presentation or approach in the course in inorganic pharmaceutical chemistry varies, although perhaps not too widely. Whether the course is given as pharmacy or pharmaceutical chemistry is responsible for some of the variation. I shall not attempt to delve into the special methods used by teachers of pharmacy. Pharmaceutical chemists, in general, follow one of two or three procedures. One is the classical method of presentation familiar in many textbooks of inorganic chemistry and exemplified by the widely used book by Rogers, Soine and Wilson, Inorganic Pharmaceutical Chemistry (6) and also used in Remington's Practice of Pharmacy by Cook and Martin (7). Another manner of approach is that propounded by the late Edward Kremers at Wisconsin and used by his students, Parks, Jannke, and Harris, in their Inorganic Chemistry in Pharmacy (8).

As you all know, the first method begins with a discussion of oxygen, then hydrogen, and then the hydrides of oxygen: water and hydrogen peroxide. This is followed by nitrogen along with its oxides and hydrides. The halogens and inorganic acids including the anions involved are discussed next. Then beginning with Group I of the periodic table, the metals, their salts, and hydroxides are taken up in detail with general class properties first and then the specific compounds. One might describe this system of presentation as the "cationic classification" since the sodium salts are discussed together, the magnesium salts together, and so on. Although textbooks list the salts of any one metal in convenient alphabetical order, many instructors prefer to make their presentation in such a manner as to discuss the more similar compounds together. For example, under sodium they would consider the sodium halides together, sodium bicarbonate and sodium carbonate together, and the sodium salts of the simpler organic acids as a group.

The Kremers method might similarly be referred to as the "anionic classification." Here elements and compounds are taken up according to the groups in which the elements occur in the periodic table working from Group VII through Group I. Under each group are discussed the free elements, their hydrides, their hydroxides (oxyacids), their oxides, and the metallic salts of the hydroacids and oxyacids. In this system all the chlorides are considered together, all the sulfates, all the nitrates, all the carbonates, et cetera. Each of the major classes

(elements, hydrides, salts, etc.) are discussed as to history, occurrence, methods of formation and preparation, physical and chemical properties, uses, and examples.

A third method which is something of a combination of the first two is used by some teachers of inorganic pharmaceutical chemistry. Here the nonmetals and their hydrides and oxyacids are presented as in the Kremers approach. Then the metals of Group I and their hydroxides are discussed, following which the salts of these hydroxides and the Group VII acids are presented, then the salts of Group VI acids, and so forth. The metals of Group II, etc., are then developed similarly. In this way the sodium salts are discussed together. the calcium salts, et cetera.

I do not propose to argue the merits of any method of approach in this paper. Perhaps some of you will wish to do so in the discussion period. Essentially the same material is covered in each method. The instructor may choose whichever seems the more logical to him, and this will be dependent upon where he got his own training or perhaps on whether administrative pressure has been applied. Let me emphasize that these are only methods of approach, and how closely the instructor follows them will be influenced by his own ideas. As I pointed out in my opening remarks, we pharmaceutical chemists are pretty independent "cusses," and thus many variations of method will be found. Some may follow a textbook closely, and others may use it only as a reference. Most will exercise the prerogative of emphasizing what they want to and varying the order of discussion.

Let us turn our attention now to the content of the course in inorganic pharmaceutical chemistry. Any course should begin with a review of fundamentals. No self-respecting football coach would dream of opening his fall training program with his most complicated trick plays. Practice on fundamentals must come first. Too many college professors make the false assumption that their students are well versed in fundamentals and that they may therefore begin on page 65 of the text and dismiss pages 1-64 with a wave of the hand and the comment that, "You already know this." Perhaps they should know it, but the cold, unvarnished truth is that a rather high percentage of an average class does not know it or has forgotten many details which a brief review would recall. Also, many of our transfer students are a year or more removed from their general chemistry. As we come into the "two plus three", five-year programs this will be especially true. I have found to my alarm, and I am sure that many of you have had the same experience, that many of the things which I would consider as essential fundamentals have been glossed over all too lightly in general chemistry. Specifically, I refer to nomenclature, valence, the periodic table, and definition of important terms. Frequently, students come out of their general chemistry courses as "whizzes" at working problems and getting answers, although few know for sure just what they are doing, but not many can name a relatively simple compound from its formula or vice versa. Many do not know the common valences of the most important elements. Perhaps one in five can tell you the difference between hydration and hydrolysis.

Some teachers take the attitude that they need not waste their time on those students who for some reason are deficient in these fundamentals and consequently teach over their heads to only the better students. Such procedure is to my mind indefensible in view of the fact that we still graduate those students who just make their 2.0 (C) grade point average, and we owe it to the profession and to the public to make them as proficient as possible. I do not mean to intimate that we should reteach the courses in which they were supposed to have been indoctrinated, nor do I think it is necessary. Many times all they need is a simple, logical explanation or a brief review to keep from being left behind in confusion. I subscribe that the students entering our colleges today must be led through their learning of the fundamentals -- yes, spoon-fed if necessary -- because they must acquire a mastery of these fundamentals before we can stimulate original thinking in them. Let's take the time to show them the way and the light; let's come down from our high and mighty perches and speak to them on their own level if need be, simplify things as necessary, and point out applications wherever we can. Let us not forget that we are teachers and as such have a sacred responsibility to impart not only facts and gems of knowledge, but also understanding and the ability to apply what is learned.

Just what should be taught in the course in inorganic pharmaceutical chemistry? In view of the foregoing comments on fundamentals it will be no surprise to you that in my own course, which is by no means unique, I begin with a review of the periodic system of the elements and of atomic structure which, of course, go hand in hand. These items lead naturally into a review of valence. Following this comes a discussion of general terms and definitions and a résumé of the important types of reactions and ionization. Concluding this review of fundamentals is a review of nomenclature. This latter is to my mind one of the most basic and important principles to be mastered. I am continually perturbed by the number of students who enter this course with only the vaguest of notions of the differences between "ous" and "ic" acids, of what an acid salt is, et cetera. A working knowledge of nomenclature is mandatory if the instructor is to develop the subject matter to follow. The few lecture periods spent in review prove well worth the time in dividends received. Many students have come to me at the conclusion of this introduction to the course and have commented that they wondered why these things were not pointed

out to them in a way they could understand before. Several have said (and I report this in all humility) that they wished they could have had this material before they began their general chemistry as it would have been much clearer to them.

With the foundation firmly in place the instructor may now proceed to the presentation of the main subject matter of the course. Having selected the method of approach which appeals to him, he can discuss the various classes of compounds according to some general pattern such as the one described below. At this point the discussion should be of a general nature, concerned with classes of compounds rather than with specific substances, except as is necessary to illustrate and amplify. First, if time permits, may come a brief historical résumé. This lends interest, gives life to the subject, and provides for greater appreciation of the progress which has been made in chemical science. Secondly, the general occurrence and sources of the particular class should be presented. Depending on the geographical location of the college, much "local color" can be injected here. Next a discussion of synthetic procedures and methods of purification and preparation is in order. Since the time available is usually limited these should be limited to methods of outstanding commercial importance. If any of these preparative methods involve reactions also used in purity and identity tests, illustrative use may be made of them here.

Another very important phase of the course is the discussion of physical and chemical properties. This information will probably be of the most practical value to the future practitioner as he actually uses these compounds. Reference may be made here to the general incompatibilities, other identity and purity tests, and other factors which are important for the class of compounds under discussion. Finally, a brief review of the general uses of the class is essential and will add considerable interest. I should like to emphasize, however, that for several reasons the instructor should not attempt to teach the pharmacology of inorganic medicinals in this course. First, the student at this point in his academic career is not prepared to understand it. Second, most pharmaceutical chemistry teachers are not qualified to teach it, and further, such a discussion rightfully and logically belongs in the courses in pharmacology.

The foregoing has referred to the material to be discussed in connection with the major classes of compounds on a general level, and, following the presentation of this material, the specific substances comprising the classes should be discussed. Here the instructor should point out similarities to and at the same time emphasize the exceptions to the general statements previously made. For example, certain compounds may vary in their chemical or physical properties or methods of preparation from the typical members of the class. These variations give the compounds individuality and should become familiar to the student. One should guard against the course becoming strictly a "monographic" study of compounds rather than a study of chemistry and pharmacy. Some instructors reportedly require their students to memorize eight or ten "points" about each official compound and even take the time to read the official monographs verbatim. In my opinion this is a waste of everyone's time. I do think, however, that nomenclature such as official English titles, synonyms, and chemical and common names should be emphasized. In his increasingly important position as a consultant in drugs to the other members of the health professions, the pharmacist should know his drugs "by their first names, last names, and nicknames."

Although the greatest emphasis will necessarily be on official compounds, others which are frequently encountered by the pharmacist should not be neglected for reasons which were mentioned earlier. The question of just what specific compounds in a given class should be most emphasized can be answered only after consideration of several factors. Prescription surveys can be of great assistance in illustrating those inorganic chemicals which are frequently prescribed. One must assure himself that the survey data he is using are not obsolete by using information from continuation surveys, if available. By keeping constantly in touch with the literature, both professional and commercial, and by close contact with practicing pharmacists, the instructor can keep abreast of what is currently important in nonprescription items. Close liaison with the pharmacologist can provide information as to what substances are therapeutically obsolescent or valuable and will indicate where emphasis or de-emphasis is necessary.

What credit and how much time should be devoted to the course in inorganic pharmaceutical chemistry? I would recommend that it carry four quarter hours or three semester hours of credit. This would provide for from forty-four to forty-eight didactic hours of instruction, which should give the instructor ample time to develop the important phases of the subject matter. It is realized that more time could be spent if one wanted to give the course a more exhaustive treatment, but present-day pharmaceutical practice does not justify it. The instructor must make judicious choice of material in light of its importance and use his time wisely. The report on physical sciences (1) recommended two semester hours of credit for thirty-two didactic hours. It is my considered opinion that these two-hour courses tend to be too dilute and consequently of little value. The instructors in such courses would probably try to cover as much material and demand as much of the student as if it were a three-hour course and I have always believed in giving the student all the credit he earns. If laboratory is given with the course, an extra semester or quarter hour of credit should be given. This

would presuppose the offering of one two- or three-hour laboratory per week for the term.

Let us consider now the matter of laboratory work in this course. Laboratory is unquestionably a valuable and important teaching tool for the illustration and demonstration of the principles presented in lecture. The types of experiments usually performed in inorganic pharmaceutical chemistry laboratory may be grouped into three major classifications: (1) synthesis of inorganic chemicals, (2) tests illustrating physical and chemical properties such as incompatibilities, solubilities, and identity and purity tests, and (3) the manufacture of galenical preparations containing inorganic chemicals or involving inorganic reactions in their compounding.

Syntheses of inorganic compounds important in pharmacy may be used to illustrate the various type reactions discussed in lecture. They also serve to give meaning to some of the identity and purity tests and provide an appreciation of some of the problems involved in the manufacture of chemicals. One cannot overlook their value in the development of technic.

Of most direct value to the future practicing pharmacist is the second group. In these experiments he gets the "feel" of inorganic compounds. A solubility description in the U.S.P. is just so many words which will not impress the student as will actually observing its solubility behavior in the laboratory. In fact, he may find that some of his preconceived notions about the properties of compounds, as gained from reading or lectures, are considerably different in practice. Here, he may actually observe incompatibilities as they occur and can see for himself the means by which they may be prevented. My only concern over this type of laboratory work is that the large number of "test-tube tests" which must be made can become infinitely boring, and many students will substitute "graphite analysis" for actual work. The temptation to split up the work among several students is another ever-present problem, and the pedagogical value of an experiment is proportionally reduced. Also, when a large number of tests must be made, confusion sets in, and the remembering process is retarded.

I have serious doubts about the advisability of having students prepare galenicals in this laboratory. If the course precedes operative pharmacy, as I feel it should, then this is a case of putting the cart before the horse. The student at this point has not yet acquired the basic skills necessary for proper compounding and will consequently do a rather sloppy job of it. It is important that a student be required to exert the same care and neatness in compounding a galenical preparation, whether he does it in the pharmaceutical chemistry laboratory or in the operative pharmacy laboratory. All too often students gain the impression that they may get away with poorer housekeeping in the chemistry laboratory, and, after personally inspecting a considerable number of chemistry laboratories, I am not so sure that they are not justified in this impression. The care and skill exercised will depend considerably, of course, on the supervision exercised by the instructor; however, it is my opinion that such preparations are best included in the operative pharmacy laboratory.

In view of the greatly decreased frequency of use of inorganic chemicals in pharmacy and medicine, I feel that the de-emphasis of the course in inorganic pharmaceutical chemistry would best be applied to the laboratory. Many schools no longer offer a laboratory in this course, and I will agree that it may be omitted without serious loss. In fact, if an extra didactic hour can be gained by dispensing with the laboratory, I believe the course would be improved. With only 7 to 12% of the 1952 prescriptions requiring compounding and only a small percentage of these involving inorganic chemicals, it can be seen that the occurrence of incompatibility is quite rare, and will diminish even more. The identity and purity tests which might be illustrated in the laboratory have, for the most part, already been done in qualitative analysis and need not be repeated here although, as I have taken great pains to point out, a review is advantageous. Galenicals can and should be prepared in operative pharmacy, and the synthesis of inorganic chemicals, although possessing some pedagogical value, is not of sufficient importance to warrant extensive laboratory work. Since this course may be the first professional course the student takes, some may argue that it is an ideal place to teach technic, but my belief is that the proper place for such teaching is in the course in fundamental principles and processes of pharmacy and in operative pharmcy.

In summary, let us review briefly the case for the course in inorganic pharmaceutical chemistry. Modern prescription practice shows a greatly reduced frequency of use of inorganic chemicals in the compounding activities of the pharmacist. From this it follows that a decreased emphasis on the course in indicated. Continued inclusion in the curriculum, however, is justified by the following: first, the pharmacist must still have the basic knowledge gained here in order to be prepared to compound any prescription; second, he handles many inorganic chemicals in non-prescription transactions; and third, this course provides necessary foundation material for the other courses of the pharmaceutical curriculum. A three credit-hour semester course or a four credit-hour quarter course is deemed adequate for presentation of the subject matter. Laboratory work may conveniently be eliminated, but if given, should add an extra hour of credit. The prerequisites, methods of presentation, and content of the course have been outlined. Finally, may I again enter a plea for emphasis on fundamentals at the outset and inspired, consecrated teaching throughout.

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A COURSE COMBINING QUANTITATIVE AND QUALITATIVE ANALYSIS

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The steadily increasing demands for more and more material to be included in our curriculums, especially in those of the professions such as pharmacy, have made it necessary to select with greater care the subjects really necessary and to eliminate or abridge some studies to leave time for others. As an illustration of the problem, there is now a strong demand for an increase in the social studies, this demand being justified by the fact, admitted I believe by most of us, that a pharmacist must take his place as a member of a social group and play an integral part in the functioning of this group.

To give more time for these other studies, the trend has been to combine general chemistry and qualitative analysis into a single one-year course. For a limited group of superior students who have had a better-than-average course in high-school chemistry, this may work out well. Starting next fall we are trying this experiment here at the University of Michigan. But for the average student who has had the average high-school chemistry, we feel that this is not the best solution. The amount of theoretical material that must be covered -- mass relations, solutions, ionization, mass law, equilibria, etc. -- is too great for the time available, and all except the superior students are rushed through the necessary fundamental studies at a pace that reduces much of it to memorization of formulas, with little appreciation of the basic relations that exist.

A second way of attacking the problem is to combine qualitative analysis and quantitative analysis into one course. In this case the student will have had the advantage of a full year of college general chemistry as well as a firm foundation in both theoretical and descriptive chemistry and will be well prepared to carry this over to its applications in analytical chemistry.

A start in this direction was made here a number of years ago when Professor Carney developed a four-hour course at the request of the College of Engineering. This course devoted about two-thirds of the laboratory time to qualitative analysis and one-third to quantitative analysis. Since no balances were used, the latter was entirely volumetric, the weighed standards being prepared for the student.

Over the years this course gradually attracted other students, until these, for the most part interested in one or the other of the biological sciences, far outnumbered the engineering students. The reason for this trend seems to be that while time does not allow these students to take our regular course in quantitative analysis, they nontheless feel a need for some familiarity with the basic operations for use in such further courses as biochemistry and the botanical and zoological sciences. Some few medical schools have recognized this by accepting this combined course as fulfilling their quantitative chemistry requirement.

With the introduction of semimicrotechnique and the resulting economy of time in the laboratory -- the consensus seems to be that the same amount of work can be done in about two-thirds of the time -- it seems reasonable to go one step farther and develop a four-hour course in which the laboratory is half qualitative and half quantitative, and to give the basic operations in both gravimetric and volumetric work. While we all readily agree that such a course cannot give the experience in quantitative analysis required of the professional chemist or of those interested in doing research in many of the branches of pharmacy, we do think that the man who graduates in pharmacy and then enters his profession will be reasonably well equipped for the problems he will meet.

Starting next fall, we are trying out such a course here. The precise outline has not yet been determined, but the general schedule will be about as follows:

Credit. 4 semester hours.

Time given to course: 3 hours of combined lecture-recitation and 6 hours of laboratory work each week.

Classwork. A general discussion of the techniques and of the basic chemistry of the analytical work; a thorough quantitative treatment of the mass law and equilibria, including the water constant, solubility constants, precipitation and solution, ionization of weak acids and bases, pH, hydrolysis, redox reactions and their electrochemical basis.

Laboratory work. Part I. Qualitative analysis. This will constitute half of the course and be limited to the more common metallic ions. (The nonmetals are to be taken up in the previous course in general chemistry.) It will probably be necessary to omit the tin subgroup (arsenic, antimony, and tin), but it seems reasonable to believe that all the other metals studied in such a representative text as McAlpine and Soule's Fundamentals of Qualitative Chemical Analysis can be covered fairly well.

Laboratory work. Part II. Here we have somewhat less experimental basis for setting up our

schedule. The balance will be used to prepare such standard solutions as NaOH from KH $C_8H_4O_4$ or HCl from Na_2CO_3, and these standard solutions will be used in further titrations. Standard redox solutions such as $KMnO_4$ from $Na_2C_2O_4$ and I_2 from As_2O_3 will be made up and used for the determination of iron, $Na_2S_2O_3$, etc. Two or three simple gravimetric determinations such as chloride by AgCl, SO_3 by $BaSO_4$, or Mg by $Mg_2P_2O_7$ will be run.

Dean Rowe of the University of Michigan College of Pharmacy is replacing the separate courses in qualitative and quantitative analysis by such a combined course for those students planning to enter retail pharmacy. We hope this course will also meet the needs of other groups who, because of the other demands on their time, find it impossible to take the separate courses.

SHOULD QUANTITATIVE ANALYSIS AND DRUG ASSAY BE GIVEN AS A UNIFIED COURSE?

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Webster's New Collegiate Dictionary gives the following definition or explanation for the word drug. "drug: 1. Any substance used as a medicine, or in making medicines; also, formerly, any stuff used in dyeing or in chemical operations. 2. An article of slow sale, or in no demand; as, a drug on (or in) the market. 3. A narcotic substance or preparation." In the same dictionary we find several explanations or definitions for the word assay. "assay: 1. Trial; attempt; essay. 2. Examination and determination as to weight, measure, quality, etc.; test. 3. Analysis, as of an ore, drug, etc., to determine the presence or absence of one or more ingredients. 4. The substance to be assayed; also, the tabulated result of assaying." When assay is used as a verb the definition is, "1. To try; attempt; also, formerly, to test. 2. To subject to assay, or analysis. 3. To appraise critically."

There is every reason to believe that those in attendance at this meeting are in very complete agreement as to the meaning of the words "quantitative analysis," but there may be some difference of opinion among us concerning the meaning and use of the words "drug assay." For this reason the definitions given above are called to your attention. My personal interpretation is that a quantitative assay is the determination of the principle or active ingredient of a substance. From these dictionary definitions and from our personal definitions of the term drug assay, may we, for the purpose of this discussion, find some common ground and consider drug assay as the quantitative analysis of any substance used as a medicine or in making medicines. The word quantitative is introduced into the definition, because an assay may be either qualitative or quantitative.

Quantitative analysis is a required course for each student of pharmacy. Here he is given the fundamentals of the course and performs certain laboratory experiments to illustrate these fundamentals. At some later time he is required to assay certain official compounds or preparations in a course sometimes called drug assay. If we consider the two courses as a single course, quantitative analysis, and illustrate the basic principles and theories of the course by means of laboratory assignments dealing with compounds used in medicine, we have accomplished the purpose of the two separate courses. Such a combined course, to be successful, must be presented or supervised by teachers with a training in pharmacy and in chemistry and thus should be, and doubtless would be, under the direct control of the college of pharmacy.

Our course in quantitative analysis at the Massachusetts College of Pharmacy is given to the third-year students. We emphasize the principles of quantitative analysis, and the laboratory work consists of volumetric analysis, gravimetric analysis, and alkaloidal assaying. Two hours of classwork and six hours of laboratory work are given during two semesters. Textbook of Quantitative Inorganic Analysis by Kolthoff and Sandell is used for this course. Two other books are required, namely, the United States Pharmacopeia and the National Formulary. Mimeographed directions for the various assays comprise the laboratory manual for the course.

The class of approximately one hundred students is divided into three recitation sections for written quiz and discussion. The written quiz is graded and is usually returned to the student within twenty four hours. The person in charge of the course and two of the full-time teachers are responsible for these three recitation sections. The same three teachers, and a graduate fellow, instruct in the laboratory. The laboratory work is scheduled on two consecutive days - three hours in the afternoon of the first day and three hours in the morning of the following day, and no work is permitted in the laboratory except during these scheduled hours. Neatness, accuracy, and honesty are essential in this course. Neat attire, white coats, clean equipment, accurate work, well-prepared notebooks showing a record of the laboratory work, and well-prepared reports, both the notebooks and reports written in ink, are required of every student.

The written examinations are four in number. The final examination is an "open-book" examination. In preparation for the "final" each quiz during the last half of the second semester is of this "open-book" type.

Each student completes about seventy different assays during the two semesters. Several dilutions of each sample are prepared, and one such sample is assigned to each member of the class. The written report is passed in and graded. The student is allowed to submit but one report on any single sample. A fixed limit of error is permitted for each sample, and this limit of error ranges from .005 Gm.

per 100 cc. or grams to 2 Gms. per 100 cc. or grams, depending upon the sample and the complexity of the assay. A laboratory grade average below 80% is the exception rather than the rule, and this grade is calculated as one-half of the total grade received by the student. The number of samples assigned to each student may seem unreasonable. Please remember that when five to ten different samples are assigned for analysis, the student reports his results and repeats the analysis two, three, or more times until the correct answer is obtained. When this number of samples is multiplied by the times repeated to arrive at a correct answer, you will find that our laboratory assignments are not excessive in number and have the added advantage of removing the monotony occasioned by repeating the same procedure upon the same sample. Similar general assay procedures repeated on several different compounds has a teaching value and a motivation not otherwise obtained.

The preparation of standard volumetric solutions is an important part of any course in quantitative analysis. Each of our students prepares all of the following solutions for his own use: sodium hydroxide, sulfuric acid, silver nitrate, potassium permanganate, sodium thiosulfate, iodine, and bromine (Koppeschaar's solution).

The classroom discussion covers the general laws and principles of quantitative analysis, apparatus, weighing, formation and properties of precipitates, technique of common operations, calculation of results, the theory of neutralization, precipitation, oxidation-reduction reactions, and the use of indicators.

The laboratory samples include the following:

Gravimetric: Bismuth subnitrate, water in magnesium sulfate, potassium sulfate, magnesium citrate, sodium chloride, aluminum acetate, and mercuric chloride.

Volumetric, using standard alkali and/or acid: Sulfuric acid, acetic acid, boric acid, ammonia water, lime water, magma magnesia, solution of ammonium acetate, solution potassium hydroxide, acetylsalicylic acid, sodium salicylate, and potassium citrate.

Volumetric, using standard silver nitrate and/or ammonium thiocyanate: Sodium chloride (Mohr method), hydrocyanic acid (Liebig method), syrup hydriodic acid, ammonium chloride, mild silver protein, and mercury ointment.

Volumetric, oxidation-reduction using standard volumetric solutions of potassium permanganate, potassium dichromate, ceric sulfate, iodine, bromine, potassium iodate, sodium thiosulfate, and potassium arsenite for the assay of ferrous sulfate, ferrous carbonate, hydrogen peroxide, sodium hypochlorite, ferric chloride, sodium arsenate, iodine, potassium iodide, tincture of iodine, mercurous chloride, and phenol.

Miscellaneous assays: This group of assays includes many which you consider in your drug assay course. The samples here considered are, specific gravity and strength of sulfuric and hydrochloric acids; saponification, ester, acid, iodine values, and unsaponifiable matter of a fixed oil; dextrose and sucrose using Fehling's solution; alcohol determination; assay of compound tincture of cinchona, tincture of nux vomica, tincture of opium, oil of clove, oil of cinnamon, spirits of peppermint, and spirits of ethyl nitrite; using a crude drug, the student determines the total, volatile and nonvolatile ether extract, moisture, crude fiber, total ash, acid soluble, and acid insoluble ash.

The work as assigned does not follow the sequence given above. The student is taught the use of the analytical balance, and this requires several exercises. Either four or five students use the same balance and thus, while one group is working in the balance room, the other groups are doing some of the so-called neutralization assays. The assay of solution of ammonium acetate and the determination of alcohol are always assigned during the same period. While a student prepares a standard solution he can, during the same period, do a gravimetric assay. The alkaloidal assays are introduced at different times during the year. This arrangement keeps the student fully employed when otherwise there might be a long period of inactivity as a sample was being filtered or ignited. We also are interested in having the student gain experience in doing several things at the same time without confusing one determination with some other determination. You may be assured that our students, while in the laboratory, find their time fully, and we believe, well occupied.

"Should quantitative analysis and drug assay be given as a unified course?" During the last several minutes you have doubtless been in suspense as you wondered what answer we would give to this question. Our answer is that quantitative analysis and drug assay can and should be combined as a single unified course. We have attempted to show you how this combination of courses may be carried into effect. There is no reason for losing anything of value in the separate courses, and by combining the two courses the student of pharmacy is constantly made aware of the fact that the assay of official drugs is quantitative analysis. With the feeling of the close relationship between the theory and the practical use of quantitative analysis in his chosen profession, the student recognizes the reason for including this subject in his curriculum. When the value of any course is recognized, maximum motivation is attained.

RELATIONSHIPS BETWEEN DRUG ASSAY AND MANUFACTURING PHARMACY

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No attempt to define pharmacy could leave out the preparation of dosage forms which is the very heart of the field. Certainly, a large percentage of the medicines dispensed and sold by the pharmacist are manufactured so that in a sense one could say that manufacturing pharmacy is pharmacy. In this connection one needs no excuse for adding courses in manufacturing to the curriculum.

It is not my function, however, to belabor the necessity for or the position of manufacturing in the curriculum. It does seem well to state that a course in manufacturing for those who are preparing for community practice is wise if only because of the enrichment of background it provides. One could argue that future obstetricians need never attempt a tonsillectomy or that a corporation lawyer who intends to limit himself to the office needs no course in trial procedure or in criminal law. Such an argument is specious.

There are those in pharmacy for whom a knowledge of semiplant scale operation is vocationally essential. There will be a few community pharmacists who will manufacture to a limited extent; the majority of such persons will however make use of the private formula houses to a considerable degree.

Hospital pharmacists make and no doubt will continue to make solutions and other liquid preparations in lots of several gallons, as well as moderately large batches of ointments, parenteral solutions, and even compressed tablets. Familiarity with such equipment is essential to hospital pharmacists, if for no other reason than to disclose limitations.

A very important user of such knowledge and skill is the pharmacist allied with the pharmaceutical industry. Those who are employed by the smaller firms often find that departments and areas of work blend -- they must serve as development men, production representatives, and trouble shooters as well as in control. The basic operations of what some people term pharmaceutical engineering must be known to them. A few pharmacists will go directly into larger scaled production, and while skill is not expected of such graduates a complete lack of familiarity with larger operations would be of concern to their supervisors.

The most important group of students in this area are, however, those going into development work. Such pharmacists will be developing formulations of many kinds which must be placed into active production with a minimum of delay.

It is my judgment that the crux of such courses is not the production of skill in our students. If that is our goal we shall be disillusioned very soon when we note that a large manufacturer can teach more skill in a month than we can teach in a year. What should go on in this area is the development in the student of an awareness of the problems he may encounter and methods of approaching their solutions.

In a class in manufacturing of some eight or ten students, the student runs headlong into cases of divided responsibility. In the dispensing laboratory he may do precise and careful work or he may play fast and loose with tolerances -- but he knows exactly who is to blame. Everything except the manufacture of the basic ingredients and equipment is in his hands. But in the manufacturing laboratory the situation is different. The many operations become divided, and the tools are different. The "hay balance" bears only a superficial resemblance to a prescription balance to the student. A large mechanical mixer -- can it be as productive of intimate admixture as his eight-ounce mortar? Further, if he is critical in his outlook he will realize that powders can become unmixed also.

This brings us then to the other arm of my subject, that is, the necessity for analysis of the fruit of production. By showing the student the results of an analysis of his work, he sees that the results of this divided responsibility can lead to an acceptable product. When he sees that reasonable care produces a product well within official or comparable limits, he is confident that he can operate on such a scale effectively and safely.

Should the student himself analyze his product? In my judgment he should not. In the first place he will probably take manufacturing concurrently with or even before his course in drug assay. In the second place, he cannot spare the time from the manufacturing operation to assay. This work should be done for him preferably by instructors and graduate assistants. This service to the manufacturing student is somewhat analogous to the preparation and standardization of analytical solutions for students in drug assay. After students have learned the principles of preparing and standardizing solutions in the basic course in quantitative analysis, it is generally conceded that little is gained in repeating this experience in the applied course in drug assay. Rather in this course the standard solutions are made available

to him so that his activity can be channeled more productively into the assay problems at hand. In the manufacturing course, the results of the assay should be made available to him along with any information he may need to enable him to appreciate the manufacturing process better.

He may gain other information and attitudes also from the analytical data. Among other things he should gain an appreciation for the necessity of working closely with the analytical laboratory in formulation work. It happens all too frequently that a new dosage form is developed which is an elegant and useful preparation but is difficult and costly to assay and, what is worse, introduces a large area of uncertainty in the assay, all or most of which could have been prevented by an alternate formulation which might have been just as acceptable.

Another reason for having the products analyzed is to show the necessity for analysis during different stages of the production process. The student should know, if possible, that his granulation is right before the compression process is started; it may be that the results of the analysis after formulation will determine machine settings.

Another advantage that various forms of analysis can take is to show the student the normal variation in similar things. Compressed tablets as they roll off of the compressor appear to be as alike as "peas in the pod" when as a matter of fact it would be better to state that they are as unlike as "peas in the pod." The fill in ointment jars will differ from jar to jar for a number of reasons, including the variability in capacity of one jar compared to another. A filling machine that is set to deliver x cc. of some parenteral solution into vials or ampoules does not appear on the surface to vary, but invariably it does. This variability from needle to needle in a multiple filling machine is even worse.

In this last case some appreciation of this variability can be gained by showing the student the following data and its analysis as taken from actual manufacturing experience (1).

Table I shows hourly samples from each of four needles in a four-needle automatic filler set for a label fill of 30 cc. and a required fill of 31 cc. From this data can be calculated over-all averages and over-all ranges which by suitable statistical devices can lead to control limits. These data can then be plotted as a standard statistical quality control chart from which it would be seen readily that something is amiss in that there are too many points out of control. Yet a look at the table indicates a fairly uniform fill at a satisfactory level. This gives an opportunity to point out to the manufacturing student some of the different sources of variability and how they can be combined more advantageously to indicate the degree of control. In this data are three sources of variability: (a) variability from hour to hour; (b) variability from needle to needle; and (c) variability between vials filled at the same time through the same needle. One of these sources of variability is measured through the range chart, namely (c). The other sources are operating through the average chart, and it is evident that the needles are filling at different levels. The variability of triplicates from the same needles is very small,

TABLE I

Record of Filling Isotonic Solution with Averages and Ranges Computed

(Measurements accurate to 1/4 cc.)

	Lot No. 500 Date: 5/12/47					Machine: Automatic Four Needle Filler					Label Fill: 30 cc. Required Fill: 31 cc.
Needle No. 1	Samples of 3			X	R	Needle No. 3	Samples of 3			X	R
1st hr.	31.0	31.0	31.0	31.0	.00	1st. hr.	31.5	31.5	31.5	31.5	.0
2d hr.	31.0	31.0	31.25	31.1	.25	2d hr.	31.5	31.5	31.5	31.5	.0
3d hr.	31.0	31.0	31.0	31.0	.00	3d hr.	31.5	31.5	31.5	31.5	.0
4th hr.	30.5	31.5	31.5	31.2	1.00	4th hr.	31.5	31.5	31.5	31.5	.0
5th hr.	31.5	31.5	31.5	31.5	.00	5th hr.	31.75	32.0	31.75	31.8	.25
Needle No. 2	Samples of 3			X	R	Needle No. 4	Samples of 3			X	R
1st hr.	31.0	31.5	31.5	31.3	.50	1st hr.	31.50	31.50	31.50	31.5	.0
2d hr.	31.0	31.0	31.0	31.0	.00	2d hr.	31.75	31.75	31.75	31.8	.0
3d hr.	30.0	31.0	31.5	30.8	1.50	3d hr.	31.75	31.75	31.75	31.8	.0
4th hr.	31.5	31.5	31.5	31.5	.00	4th hr.	31.75	31.75	31.75	31.8	.0
5th hr.	31.0	31.0	31.0	31.0	.00	5th hr.	31.75	31.75	31.75	31.8	.0

being zero in fifteen out of twenty samples. The control chart system is set up so that the consistency of two causes of variability can be checked. In this case, the variability between needles at the same time can be checked with replicates from the same needle or with the variability of the process over a period of time, but control charts, such as the one which would be plotted from the data of Table I, are an attempt to check the variability of triplicates from the same needle against combined time variability and variability between needles. In this particular case the replicates have nearly zero variability; hence it is better to combine this variability with the variability between needles and check this combined variability against that of the process over a period of time.

A second major fault in this way of looking at the process is the fact that the time variable is consecutive within the needles but not for the process as a whole. By shifting the variability between needles to the range chart, this will be corrected.

By looking at the whole process in a little different manner, a much better picture of the natural variability of the process can be obtained. The new system involves taking one vial from each needle hourly and computing the average and range of this subgroup of four, as indicated in Table II. These data may be charted also into control charts which would show that the process is in control during the period of the production and that the variability between the needles is in control as would be seen from the range chart.

Data of this type and its subsequent analysis should not be presented usually for the point of the student seeing through the rather involved statistical analysis, but rather so that he can see some of the sources of variability and get some appreciation of its measurability.

A somewhat similar control chart analysis has been developed for the weights of subgroups of five compressed tablets taken from a single punch tablet machine in the University of Wisconsin manufacturing pharmacy laboratory. A glance at the chart would show that in general the process was in control, but at two different points the machine was out of control and in one case needed correction. In the other case the machine corrected itself, indicating to the student the fact that a holdup of granulated material can occur and should be guarded against. There is, however, another illustration of the advantage of the control chart technique in this example for it shows that there is a relatively long period when all points on the chart of average weights are on the same side of the mean line. Since the points are normally scattered this is indicative of an error in the process which will probably lead to error sooner or later and that some action should be taken.

During the manufacturing course the student should also have an opportunity to become somewhat familiar with the many factors involved in tolerances. In the case of a given official tablet the permitted tolerances may be between 95 and 105 per cent. When such tolerances were established it was never the intent that the producer would manufacture

TABLE II

Subgroups of Four Across Needles With Averages and Ranges Computed

Hour	Needle Number				X	R
	1	2	3	4		
May 13						
8:15	31.25	31.00	31.25	31.50	31.25	.50
9:25	31.00	31.00	31.50	31.50	31.25	.50
10:15	31.00	31.50	31.25	31.50	31.31	.50
11:30	31.00	31.25	31.50	31.50	31.31	.50
1:10	31.25	31.00	31.50	31.75	31.38	.75
2:00	31.25	31.00	31.50	31.50	31.31	.50
2:50	31.00	30.50	31.50	31.75	31.19	1.25
3:50	31.00	31.00	31.50	31.50	31.25	.50
May 14						
8:15	31.00	31.25	31.50	31.50	31.31	.50
9:05	30.50	31.50	31.25	31.75	31.25	1.25
10:10	31.50	31.25	31.50	31.75	31.50	.50
11:00	31.25	31.50	31.50	31.75	31.50	.50
12:40	31.50	31.00	31.75	31.75	31.50	.75
2:05	31.50	31.00	32.00	31.50	31.50	1.00
3:10	31.00	31.00	31.50	31.75	31.31	.75

at or near the limits. In fact if his machine setting, granulation, -- et cetera is set at the 95 per cent level, a great share of the time the tablets would actually be outside of the limit. In fact with a knowledge of certain statistical parameters it would be possible to determine the probability of accepting and samples of various sizes based on such manufactured lots. The student should be taught to recognize that in order to assure compliance with the official limits, he must manufacture within much narrower limits. He must recognize also that there is an analytical tolerance created by the fact that the best method carries with it errors and biases and that the same analyst on different days and the different analyst on the same day, and analysts in different laboratories, will obtain different results. By collecting data over a period of time and making this data available to the student, this awareness can be brought about.

An example by Evers (2) summarizes briefly this concept. If the populations of tablets were produced so that its mean was exactly on the manufacturer's safety limits samples will almost always lie within the official limits, assuming, of course, that the manufacturer's safety range rests upon secure statistical information. A lot with a mean directly in the lower official limit is as apt to be unsatisfactory as it is satisfactory. On the other hand if the analyst gets results corresponding to his safety limit, the tablets may come from the batch with the mean on the lower official limit, but they are just as apt to come from the batch having much lower limits so that the analyst would probably wish to make one or more additional determinations. This is illustrated graphically by Evers (2).

To the producer, as well as to the consumer, it is good to know the likelihood that an analysis based on a small sample will accept a bad lot or reject a good one, for in the former case the producer is running a risk of action by the enforcement officials and in the latter, an economic loss. Very probably the manufacturing course will not have the time for going into the statistical evaluations of such a procedure, but the student can be shown the results of such calculations based on actual classroom data collected over a period of time. Operating characteristic curves for the weights of the contents of dry-filled ampoules which the author was privileged to make some time ago illustrate this principle (3).

To summarize, it is the author's thesis that the manufacturing student should have access to analytical data on his and other classroom products. Such data serves to bring an awareness of variation in things that are allegedly uniform and the problems involved in tolerances. Perhaps even more important to those who go into small lot manufacturing in stores, hospitals, and industry, it gives them confidence in their ability to work on a larger scale.

You will note that nothing was said about the analysis of products manufactured in the classroom for actual consumption. It is so obvious that such products must be analyzed for public protection that there is, in my judgment, nothing more to be said.

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UNDERGRADUATE INSTRUCTION NEEDED IN ANALYTICAL PHARMACEUTICAL CHEMISTRY FOR INDUSTRIAL ANALYTICAL CONTROL

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It is not going to be easy for me to talk to you on the subject of Control and Analytical Chemistry, and still make it interesting. This is a subject that is generally considered so prosaic that in a popularity poll I am sure it rates somewhere down around the bottom for all the different branches of chemistry in which the graduating student in pharmacy or in chemistry feels that he might be interested.

Yet analytical chemistry is basic, it is fundamental; it is an important part of the manufacturing operations in practically every industry today, and especially, of course, in the pharmaceutical industry. The chances are pretty good that a graduating senior in pharmacy or in chemistry at the Bachelor's level, if he is at all interested in laboratory work -- the chances are that he will end up doing analytical work, whether it is in the Research Division, Products Development, Process Development, or in Control, so it may be worth our while to spend a few minutes talking about this branch of chemistry.

I am tempted now, of course, to use up your time to talk about the history and the development of the science of analytical chemistry, how it has progressed during the past twenty-five or twenty-seven years that I have been associated with it to take its place today as the principle instrument of measurement of chemical science without which progress in research or other technical developments would be slow if not almost impossible.

But I won't take up your time that way. I note that some phases of the subject have been touched upon by those who have preceded me on this program and that it will be discussed further by some of those who follow me. Moreover, there are numerous articles already published on the role of analytical chemistry in industry which I am sure most of you have read.

I have been told to do two things here today, first to talk less than thirty minutes, which I will have no trouble in doing, and second, to stick to the subject assigned to me which is limited in scope and which I may have a little more trouble in doing. In order to satisfy both requests I have prepared a script and I hope to be pardoned if I refer to it and read from it often throughout this discussion.

In my position, at least during the past ten or twelve years, I have had the responsibility of hiring quite a number of pharmacists and chemists, mostly at the bachelor's level, for the analytical laboratories. And I have had the job of firing some of these.

I am supposed to have some very definite ideas on what the students should be taught in order to make them into analytical chemists. Perhaps I have expressed some opinions in mutual discussion with those of you that I have had the opportunity to see more often, and you may have disagreed with me and perhaps even proved that I was not quite right. Since I presume that I am expected to offer some criticisms here today, I sat down a few days ago in an attempt to list these criticisms in the script and I found that there was not much that I could justifiably criticize with any degree of definiteness. I concluded that maybe you are not doing such a bad job after all. Actually you are not; I think that you are doing a pretty good job. The men that come to us are in general adequately trained in the fundamentals of chemistry and I think you should be complimented.

I don't see how we can expect you, in the four years that you have these students available to you, when you are expected to teach them something else besides chemistry, to prepare them for pin pointed employment, such as in the analytical field, any more than we can expect the Engineering School, for example, to train their students specifically to build bridges.

All that we can expect is that the student is trained in the fundamental principles of the different branches of chemistry. All of them are used in the Analytical Laboratory. A comprehensive training in these fields gives one the basic attitude necessary for the expeditious solution of analytical problems, and a man with this good basic academic training, given the necessary intellectual qualifications, can be further trained by us on how to use - or at least, and what is perhaps more important, when to use - the multitudinous analytical techniques now at our disposal.

It will not escape notice that I am going to give no formula for the making of an analytical chemist, I am not even going to define a good analytical chemist, nor do I believe that employers of pharmacy graduates in other fields of pharmacy could for your benefit define a good retail pharmacist, a good product development pharmacist, a good market analyst, detail or salesman, or a good manufacturing pharmacist. Yet pharmacists are employed for each of these specialized fields and also for other fields.

There are current proposals to set up special curriculums for training pharmacy students for specialized employment. I think we should be very cautious about moving too far in that direction.

The courses that should be offered at the undergraduate level, in my opinion, are those dealing with basic principles and ideas. Detailed information in specialized fields can be obtained from books and practice. Good doctors and good lawyers develop only after years of experience and further study beyond the professional schools. Not all who graduate become good. Only a few become great. Why should we expect more of pharmacy graduates?

But this discussion is supposed to be limited to analytical chemists and you might at least be interested in some of my general observations.

1. Pharmacy graduates do not always have a good fundamental training in the different branches of chemistry.
2. Graduates of pharmacy schools where chemistry is taught in chemistry departments in competition with other chemists -- these are the best trained for laboratory work.
3. Given this equal training in chemistry, there is not much difference between a pharmacist and a chemist.
4. Initially, the pharmacist becomes an asset to us a little faster because he has learned to associate chemistry with drugs and medicines. He knows something about the U.S.P. and the N.F., the official compendia, which, after all, are loaded with analytical chemistry.
5. In the long run the chemist surpasses the pharmacist in investigatory skill, aptitude, and desire to do analytical research.
6. The pharmacy graduate who does not have basic training equivalent to that of the chemist may fail and has failed in the laboratory, or at the very best his progress has been comparatively slow. He generally ends up somewhere in the plant doing other than laboratory work.

Now, to get down to the undergraduate training needed for industrial analytical control. It would be futile for me to attempt to dictate to you men a four-year curriculum designed specifically to train pharmacy students for analytical chemistry. None of us would agree anyway, least of all yourselves. I will not attempt, nor am I qualified to tell you how to be better teachers. I am sure that all of you have read the recent publication by Hildebrand, in the Chemical and Engineering News, "The Making of a Teacher," in which at the very start he quotes in speaking of teachers and the subject they teach, the following: "I encourage them to see its importance to endeavor to do it well, and not to cringe before those non-teachers who dictate to them as to how it should be done."

With that admonition I should end my talk right now. But I think you would be interested in knowing a little something about what we expect of an analytical chemist in a pharmaceutical laboratory, and just as importantly what he can expect of us.

Let us assume that you are across my desk being interviewed for a job in our Analytical Laboratories. Let us assume also that what is said in this interview would be quite similar for any other large pharmaceutical house. The interview would last for about one hour and I shall condense it here to a few minutes.

For the first ten minutes we would talk about things in general, but mostly about you. We would attempt to learn something about your training and personality. There are no definite specifications for the raw material interviewed nor do we have any set pattern of questions, but we would attempt to establish whether you would be compatible with the other forty members of the analytical staff.

We would then continue our interview something like this: The work in this laboratory is entirely chemical in nature, physiological and biological testing are done in our other laboratories. Unless you have a good basic training in chemistry your work here will be difficult, and you will be no particular asset to us.

The primary function of this laboratory is clear cut: It has the responsibility of properly controlling products without serious delays in our production schedules. This includes the analysis of all materials purchased that become a component part of our products, all chemicals manufactured by us including the intermediates and, of course, the finished products.

On account of the great variety of products in which we are actively interested, which total about 5,000, there are but few types of determinations that this laboratory is not called upon at one time or another to carry out. There will be some routine on this job, but it does not make much difference what kind of a job you decide to work at, some routine will be involved. There is routine in my job, there is routine in our president's job, -- some things must be done in about the same way every day.

Many young graduates express a desire to do research work, and that is quite understandable. The word "research" has an undefinable magic, it fools a lot of people; it means search and search over again; you play with chemistry. Well, you don't play with chemistry in industry, you work with chemistry. Research is organized today to the point where you are quite often a member of a team assigned to one specific and sometimes narrow phase of a problem.

Contrary to common belief, the analytical chemist is no longer considered just a routine analyst, hidebound by classicism in methods and technique. In every analytical laboratory there are opportunities to improve methods. This offers a challenge to the investigative mind to invent or adapt new apparatus and techniques, new reactions and instruments.

In this laboratory about 25 per cent of your time is available to do investigative work. You will not have that much time every day because your time will be governed somewhat by production schedules, but that will be the average. Some problems are assigned to you but generally you have the liberty of selecting your own problems which will occur to you in the course of your regular control duties.

Collaborative studies on assay procedures with Committees of Revision of the United States Pharmacopoeia and National Formulary, the Combined Contact Committee of the American Drug Manufacturers Association and the American Pharmaceutical Manufacturers Association, the Federal Food and Drug Laboratories, the National Institute of Health, the American Medical Association, and other agencies are assigned to those in the laboratory who are routinely doing a similar type of work. With the exception of one specialized section in the laboratory that devotes full time to the development of specifications for new products, we have not divided the work into strictly research and strictly control.

Problems in production are jobs which for the most part end up in the Analytical Department. Our laboratory plays, to a considerable extent, the part of a general chemical consulting unit and a clearing house for numerous problems originating outside of the department. We are the best fitted for this part because we, of all divisions, have the most direct contact with production, development, and research groups.

We have here a well-stocked library which we encourage and expect you to use. There cannot be much fun in doing analytical work unless you know what you are doing, otherwise we could train the janitor to run an assay once we show him what an Erlenmeyer flask, a pipette, and a burette are. We want you to be an analytical chemist, not just an analyst.

Before you decide to work in this laboratory, or any other analytical laboratory you want to be sure first of all that you are interested in analytical chemistry. You must be patient and meticulous in your work and you must be extremely honest. You must get pleasure out of starting with an absolute unknown, going through a number of laboratory manipulations, and ending with a mathematically precise answer. If you do not think you are going to like that kind of work, I would advise you to start in some other field.

Your remuneration here will be the same as for any other job in the plant with equivalent responsibilities, and your chances for advancement are just as good. But you must recognize that there is not much glamour or publicity attached to this work. We could not patent a new analytical procedure if you developed one nor would we collect royalties on it if we did. But I can assure you that if you decide to take analytical chemistry seriously, you can get out of it a great deal of pleasure.

That would end our interview and you would be advised to take a few days time to think it over carefully before deciding to enter the field of analytical chemistry.

Let me repeat that I believe, that what I said is essentially what would be said in an interview for a job in the analytical laboratory of any other large Pharmaceutical house.

Before I end this talk, I would like to take just a few more minutes of your time to read to you the comments given to me by some of your former students regarding their undergraduate training. These comments come from the younger men in our laboratory, those who have been with us for less than five years. I did not feel that the older twenty or twenty-five year members of our staff would be in a position to properly criticise modern teaching methods. Moreover, they probably have forgotten what they did not know when they graduated.

I have made no attempt to edit these comments and I shall read them to you exactly as they were given to me. Some you will judge on the humorous side, but I think that you will find all of them interesting.

Comments No. 1

In the following paragraphs you will find mentioned those phases of chemistry, which I believe should have been emphasized to a greater extent, in the chemistry courses I took in college.

I found, that while my chemistry theory was more than sufficient for my work here in the laboratory, the actual application of this theory to laboratory work was a little difficult. This can be attributed, I believe, to the fact that the number of hours of lab in college did not correlate with the number of lecture hours; we did not have time enough in lab to practice the theory we had learned in lectures.

Possibly my weakest point is physical chemistry. This branch of chemistry has grown to be the most important part of chemistry, and while I was in college it was given the least amount of attention.

I also found that my knowledge of the Chemical Journals was very meager. Their importance was not emphasized nearly enough.

Comments No. 2

Suggestions for Teachers of Chemistry in Colleges of Pharmacy

1) In many cases, teachers of chemistry have had no formal preparation and very little informal preparation in the actual art of teaching chemistry. I would suggest a prerequisite of several teaching courses before an individual be allowed to teach in a college. In addition to this, faculty and student criticism offered in constructive manner would prove of great value in many cases.

Often highly qualified persons are placed in charge of students and regardless of the individual's brilliance as to subject matter, it is possible for him to be a flop as a teacher if he fails to present the material so that a student is able to absorb the main ideas presented. Many teachers also fail to realize that though they themselves

have been over the material numerous times, it may not "stick" to the student on first presentation, or from the particular viewpoint that the teacher presents it.

2) Many times the actual laboratory operation of college chemistry courses is left to undergraduate or graduate assistants who feel they don't have the time to give more than limited help to the student, or who don't have the actual ability or experience to answer definite questions as to the "whys" of laboratory operations and procedures. I would suggest that as frequently as possible, experienced and competent instructors be available and circulating in the chemical laboratory to point out obvious procedure faults and give advice and suggestions to the students individually. In these days of large classes, it is often difficult to foster closer student-faculty associations; however, if the above suggestion were in practice, I feel it would prove an inspiration both to student and to teacher.

Comments No. 3

In considering how my college could have better prepared me for a job in this laboratory, I have concluded that the qualities I was most deficient in were:

1) Confidence in myself
2) Speed
   These two were probably the result of not enough lab work because they came to me quickly with experience.
3) Knowledge of technical instruments
   In school I had very little experience with the everyday tools of the trade such as the p pH meter, polariscope, etc.
4) Importance of the literature
   In school I worked with text and reference books with no notice given to the journal and professional magazines.

Comments No. 4

1) Put more emphasis on manufacturing pharmacy.

2) Give the undergraduate student courses in the theory and use of physical instruments, commonly found in the chemical laboratory.

3) Teach the student to be more precise in his work. Stress quality more in the laboratory in such courses as quantitative analysis and organic chemistry.

4) Encourage graduating seniors in pharmacy to look into the opportunities offered in the field of manufacturing pharmacy, especially along the analytical lines.

Comments No. 5

I have listed below a few of the subjects which I feel would have helped me greatly in my work today had I been given the basic training during my Pharmaceutical Curriculum.

(a) Full year's course in Instrument Technology
   Actual manipulation of the instruments in determinations on commercial products
(b) Detailed instructions on the operation and care of all electronic instruments
(c) Theories involved in electronic procedures

2) A full year's course in Vitamins
   (a) Origin and distribution
   (b) Human requirements
   (c) Assay procedures
      (1) Colorimetric
      (2) Chemical
      (3) Ultra-Violet
      (4) Infrared

It should be pointed out that this man's comments are no doubt influenced by his responsibilities which happen to be in a specialized field of analytical chemistry.

Comments No. 6

Following are some points which have occurred to me of academic training which, to my knowledge, are not now offered but which would be of value to the student planning to enter industry in the laboratory phase.

1) More direct supervision and guidance in laboratory courses
   Although I fully realize the difficulties on this point which are encountered in a large laboratory class, most students are graduated lacking in knowledge of relatively common apparatus and techniques. A great deal more direct supervision should be given in the laboratory.
2) Knowledge of physical instruments
   I do not even suggest that detailed descriptions of the various instruments be taught but the student could be given a brief lecture on the uses of each of the more common instruments.[1] Although he need not know the detailed electrical and optical theories involved, he should be given the opportunity to know the uses of the instruments. If it is impractical to let each student operate the instruments, this could be done by demonstration. This knowledge can now be gained in advanced courses, but I believe this introduction of which I speak should be offered in an elementary course.

Comments No. 7

I recall at the present these items which would have been of some help as background for doing analytical work:

1) More mathematics -- especially logarithms
2) Some physical chemistry (pH determination, spectrophotometer, etc.)

[1] Spectrophotometer, photoelectric colorimeter (Lumetron, Evelyn, etc.), photofluometer, nephelometer polarimeter.

3) Biochemistry
4) Better knowledge of library system of cataloging the books and proper method for looking up references
5) A little knowledge of statistical method for chemistry
6) Organic Analysis (quantity and quality)

Comments No. 8

These are a few changes which I would recommend, based on my college training:

1) More emphasis on the fundamentals of chemistry and pharmacy, i.e. more stress on basic laboratory procedure and basic chemical theories and laws
2) A more rounded program to choose from with courses, other than the major, to receive less stress by the instructor, i.e. there is a tendency on the part of many instructors to feel his or her course is the only one being offered, and consequently the student has to forego his major study to satisfy the whims of a professor in another field. A student should not be failed in a course that isn't his major.
3) Less emphasis on grading students; too much emphasis is placed on quizzes and final exams, whereas daily work should carry the burden. The course should be fitted around the student rather than the student to the course.

That is what the man said!

Gentlemen, those are the comments from some of your former students, insufficient of course for statistical analysis and perhaps not even helpful but interesting, I am sure. You may be able to pick out those that have the better fundamental training.

I can now anticipate your question, "Just what is basic and fundamental training?" I will not attempt a direct answer, perhaps there is none. I will only repeat that one of the most serviceable fundamental bases for research in analytical chemistry is a thorough indoctrination in the methods, techniques, and approaches of so-called classical gravimetric and titrimetric analysis. How this should be done is your job.

I will, however, give you some idea of the kind of questions (wise and otherwise) that have been asked in our Analytical Laboratory by graduate pharmacists and chemists.

Questions Wise and Otherwise

Why don't I get a white precipitate when I add ammonium sulfide T.S. to this solution of zinc chloride?
Instead of ammonium sulfide T.S., why can't I use hydrogen sulfide T.S. and then add ammonia?
This sodium borate assays high. What shall I do?
How do you dry sodium borate?
Why is this solution of sodium hydroxide alkaline? I added a few drops of phenolphthalein T.S., and then nitric acid until the pink color disappeared, but it is still on the alkaline side.
How do you filter off zinc sulfide?
How do you dry sodium thiosulfate to constant weight?
What is constant weight?
Where is the methyl orange end-point?
What is the best way to bring the temperature of a liquid to 25° for determining its specific gravity?
Do I have any bromine in this chloroform layer?
How do you weigh out liquids?
How do you weigh out powders?
How many extractions are necessary in this assay?
When is it not permissible to use platinum ware for ignitions?
How do you clean platinum ware?
I heated some acetylsalicylic acid with water and it dissolved as expected. But now, as the solution cools, something is crystallizing out. What is it?
How do you carry out the test for iron?
How do you carry out the test for arsenic?
In testing calcium phosphate dibasic for mono- or tribasic calcium phosphate, do you first suspend the material in water, or do you add silver nitrate T.S. directly to the powder?
In testing Celite for sand and gravel, what is a trace of sand?
Does neutral litmus turn blue with alkali?
What does "very" soluble mean?
What does "freely" soluble mean?
When determining total solids in beef extract, what is the purpose of adding sand?
When the card reads "char, but do not ash," how can you tell when to stop?
Do you use a Gooch crucible just as it comes from stock, or do you have to add something to catch the precipitate?
When do you use sintered glass crucibles and when do you use Gooches?
How do you calculate the result of an assay to the dry basis?
Why don't I have to filter off the silver bromide in this Volhard assay, the same as I did for silver chloride?
How do you determine refractive index?
What is the difference between optical rotation and specific rotation?
How do I determine the factor in this titration? I can't find it in this table.

These are only typical questions, many more could be listed, all of them reflective in some way to basic and fundamental training, the kind of training that I believe we in industry have a right to expect.

Thank you gentlemen for listening.

A ONE SEMESTER SIX CREDIT HOUR COURSE IN INTRODUCTORY ORGANIC CHEMISTRY

J. O. Halford

Professor of Chemistry, University of Michigan

I shall first present a summary of the events which led up to our present policy at the University of Michigan of enrolling all beginning organic chemistry students in the same one-semester six-hour course. The rest of the time will be given to comments on the content of the course and on the values which students in the several different specializations can be expected to derive from it.

As shown in an exhibit in the display window of the prescription laboratory on the first floor of the Chemistry and Pharmacy Building, instruction in organic chemistry and pharmacy had a common origin in a single course of lectures authorized by the Regents in 1863. Later, with the rapid expansion of organic chemistry, the two fields were separated and the organic chemistry course was given primarily as required by the Medical School, in the form of a highly concentrated routine to which the student applied himself exclusively for a period of time.

This scheme subsequently gave way to a one-year course given as two consecutive one-semester five-hour courses of four class hours and six to seven hours of laboratory work each week. The Medical School then sought to curtail the required work, with the result that a one-semester four-hour classroom course covering the entire field was offered along with a two credit hour course which could either accompany or follow the classroom course.

This arrangement continued until the present year and offered the student the opportunity to start his organic chemistry by enrolling in either a one-semester or a one-year course. Chemistry majors, chemical engineers, and pharmacy students took the longer course, while predental students and most of the premedical students enrolled in the shorter one. The longer course, which was divided in the conventional manner into one semester on aliphatic compounds and one on aromatic compounds, was prerequisite to more advanced courses. On the other hand, the one-semester course, since it was not regarded as an adequate prerequisite, constituted a blind alley from which there was no recognized exit to more advanced work. This created a difficulty when a student who took the shorter course developed an intense interest in the subject and wished to continue with advanced study. Such students, if their grades were high enough, were permitted to enroll in the second half of the longer course, for reduced credit, but the arrangement was regarded as unsatisfactory because it involved omission of some important topics and duplication of others.

A further complication was introduced when the requirement for chemical engineers was reduced from ten to eight hours by cutting out half the laboratory work. Instead of expanding the number of courses by offering a special course for chemical engineering students, the problem was solved by having these students take the classroom work of the one-year course along with the shorter one-semester laboratory course. The next irregularity came with the establishment of an eight hour minimum preprofessional requirement by several of the important medical schools. Students who intended to apply to these schools could take the one-year course or the eight-hour arrangement set up for the chemical engineers, but it often happened that the applicant learned of the additional requirement only after he had completed the shorter one-semester course. There was again no satisfactory way to provide him with the additional two hours of credit.

By this time the course organization had acquired enough irregular and special features to require extension or revision. It was immediately evident that some of the difficulties could be removed by offering a second advanced, one-semester course designed to follow the one-semester combination already being given and to bring the student to the same achievement level as if he had originally taken the ten-hour one-year course. It became evident that further simplification combined with greater flexibility would be achieved if at the same time the original one-year course were discontinued.

As a result, a single one-year course is now offered consisting of a six-hour course in the first semester covering topics over the entire field and a four-hour second course designed to fill in details and provide a more intensive study of theory. The six-hour course is essentially the original one-semester arrangement, including laboratory work, and can be taken as a four-hour lecture and classroom course by special permission. Chemistry majors, chemical engineers, pharmacy students, and premedical students are required to enroll for six hours, but metallurgy and predental students and in general those who intend to do no laboratory work may enroll for four hours. In the same way, in the advanced four-hour course, two-hour enrollments for those needing only limited credit are permitted.

This makes it possible to obtain credit for four,

six, eight, or ten hours in reasonably complete self-contained courses, and to continue in a normal sequence into more advanced work after any of these exposures. Only the two courses, however, are offered, and the flexibility is achieved by permitting enrollments for partial credit and by making each course and each of its permitted subdivisions complete in itself.

A further advantage of this flexible arrangement is realized when it becomes necessary to assign additional fundamental courses to transfer students and graduate students who have had limited previous training. Assignments of two, four, or six hours can be made according to the apparent needs of the student.

The present six-hour, one-semester beginning course in organic chemistry then originated as a result of the request by the Medical School for a short course covering the fundamentals of the entire spread of the subject. This course, originally four lectures and discussions each week, has been combined with the short laboratory course originally designed to accompany or follow it. A principal reason for enrolling all beginning students in the same course is the simplicity of organization and the flexibility of handling transfer students and accommodating those whose special fields require different total exposures to the subject.

There has been no thought that the training value of the entire year course under the new six-four arrangement is necessarily any better than the two consecutive five-hour courses with their conventional break between aliphatic and aromatic organic chemistry. But the organic chemistry staff felt that the material could be presented about as effectively under the new set-up as under the older one, and that there was a definite possibility that, in time, an improvement of presentation might be achieved. The pattern for the initial six-hour course had been established while the course was being given primarily for premedical students. The real problem is the organization of the second semester four-hour course for those who require a year of organic chemistry. This course is taken by chemists, chemical engineers, pharmacists and a few premedical students and can be classified as essentially a course for professional training in chemistry. The content, on this basis, is to be selected for the benefit of students who wish to know and use the subject as professionals. Therefore, theoretical topics designed to facilitate prediction and simplify classification are likely to form an important part of the material presented.

At present the six-hour course has not deviated far from the earlier premedical short courses, and the second semester four-hour course is still under study and subject to frequent and considerable revision, having been presented, up to now, only three times.

It has been true for a long time, while the short and long courses were both being offered, that the exposure to aliphatic compounds has not been much different in the two routines. In the short course, from thirty-five to forty meetings are and have been devoted to introductory material, structural theory, systematic nomenclature, and aliphatic compounds. In the older longer course the exposure to the same material was forty-five meetings. As a result, a few topics like condensation reactions and aceto-acetic ester synthesis, previously given in the first semester, are now deferred in the six-hour course for consideration in the second semester.

The older course devoted forty-five meetings to aromatic chemistry and special topics, but the inclusion of topics on aliphatic chemistry in the second semester was not consistent with the description of the course and therefore introduced an element of awkwardness. The change in emphasis, however, brought about by the extensive development of aliphatic chemistry in recent years has created a pressure for the devotion of more time to this branch of the subject. Under the old system changes in this direction could not be made in an entirely convenient and consistent manner.

With the present arrangement, twenty to twenty-four meetings are used in the six-hour course for aromatic compounds and a few special topics, and thirty meetings are available in the second semester for the inclusion of more aromatic chemistry, some work on aliphatic compounds, and a further exposure to special and theoretical topics. It is clear that some added flexibility in the distribution of subject matter has been achieved along with the flexibility of organization which has been discussed.

In laboratory work the scope and type of the experiments is essentially the same under the new arrangement as under the older discontinued one, but the order in which the experiments are performed has been revised in the attempt to maintain correlation between laboratory and classroom work.

It has been the tradition in the University of Michigan, after a few preliminary experiments on laboratory methods have been performed, to restrict the laboratory exercises in the basic organic chemistry courses to the preparation of compounds in test tube amounts, with a few variations in the direction of larger or smaller scale work. Classification tests and group reactions primarily on the test tube scale, such as the more rapid precipitations and color reactions, have not been included. Recently, some departures from this tradition have been made, but not enough of them have been introduced to change the character of the laboratory work appreciably. While it must be admitted that such tests, particularly in combination with identification problems, can have excellent teaching value, such work is introduced only at the expense of breadth of experience in preparations and is for the most part deferred to a later course.

The six-hour course, to fulfill its function properly, must present a reasonably complete fundamental

picture of the subject. With the schedule of lectures and discussions already well filled, the fact that new information and attitudes are continually being introduced by research workers is steadily raising a problem of revision. As each new fact or discussion is introduced, the crowded schedule requires that something be abbreviated or eliminated. Since it is usually a debatable question whether the revision is an improvement, the degree and rate of revision must depend upon the judgment of the instructor. It will usually be a mistake to let the course get into a rut by insufficient revision or to go too far in the opposite direction in the introduction of new material. In the latter case there is too much danger of eliminating traditional fundamental material in favor of newer material of less general application. Since, in our present educational system, the four-year tradition is strongly entrenched and only limited space can be found in the curriculum for a single subject, any attempt to increase the length of a fundamental course is bound to encounter strong resistance. Consequently, the adjustments called for by new information and ideas developed in a rapidly changing field like organic chemistry must nearly always be made within the limits of a fixed time schedule.

It is fortunate that the initial course, which is taken by the largest numbers of students and is therefore most likely to be held to a fixed length, is the one which requires the least revision. New information usually finds a more proper place at the advanced level and exerts little or no influence upon the fundamentals with which the first course is primarily concerned. The point of view and the emphasis in classification may be subject to continual change, but the selection of experimental facts upon which a first course is normally constructed changes only slowly. Thus, a large part of the foundation of today's first course was present in the initial course of twenty or even thirty years ago.

Exactly how much material to present and what to expect of a student in the first organic chemistry course is still an open question. The field includes an enormously extensive number of experimental facts which can be linked together surprisingly well, with the aid of structural theory as a basis of classification, by a liberal use of analogy and of certain unfortunately not too complete or reliable theories. A thorough knowledge involves the acquisition of a relatively limited but actually formidable set of facts which are used, more or less in conjunction with theory, to make well-directed guesses about situations where the facts are not known. Before the now not totally reliable theories can be effectively used, a considerable body of experimental facts must be acquired.

For the student specializing in chemistry, pharmaceutical chemistry, or perhaps chemical engineering, we must try in the first course to erect a foundation upon which an expert knowledge can be built efficiently. In others who will not go much beyond the first course, we must try to imbed a few facts and develop an appreciation for what the organic chemist can accomplish and how he goes about his work, and we can encourage the student to develop the beginnings of these same abilities himself.

If the objective for this latter group includes the permanent acquisition of an extensive factual knowledge, we are bound to be disappointed. Enough systematic study has been made to show that the retention of factual material from individual courses or limited sequences of courses is extremely low even when tested only a short time after completion of the courses. We run against this factor frequently in dealing with students who retain very little from prerequisite courses, and whose poor retention often includes theoretical as well as factual material.

In designing the course, we need to consider what we would like to achieve in relation to what can be accomplished and to decide whether it is better to develop the good students and let the others get what they can, or to concentrate on the weak students and run the danger of boring the better ones. The usual course in organic chemistry in the large university tries to find a compromise between these extremes by setting the level high enough to maintain the interest of the stronger student without ignoring the needs of the weaker one. In doing this there is grave danger of sacrificing the development of the good student without enough compensating benefit to the poor one. This question could be argued at length without producing a generally satisfactory answer. It should be true, however, that in the first course the amount and difficulty of the material presented can be profitably chosen with the interests of the average or even subaverage student kept prominently in mind. It is difficult to decide how far to go in this direction and it is somewhat dangerous to tamper with a traditional arrangement which has worked out fairly well, but it is still possible that a further restriction of the material included in the first course might tend to produce a more generally effective result.

There seems to be enough reason to justify some experimentation with the amount and difficulty of the material presented in the first course. And there is a possible means of evaluating the effects by consultation with the instructors in the more advanced, closely allied courses in pharmacy, chemistry, biochemistry, and chemical engineering. In this way it may be possible to find what course content and method of presentation will insure carrying the best prerequisite knowledge into subsequent courses.

In any case we shall probably have to be content to turn out students who retain little specific information from the first course, since poor retention seems to be a normal human failing. We can hope, however, that certain intangible values have been obtained which will help the individual in later experiences, both within and beyond his formal educational program. It does seem to be true that exposure to a course improves the ability to cope with a

more advanced related course, even if the retention indicated by direct conventional examination is very low.

It seems fairly clear that there is at least this one intangible value to be derived from this course and presumably also from most other courses. If we define as intangible values any developments of ability or capacity which are not adequately tested by our conventional methods of examination, we can make a list of such values and look for ways of testing for them or for indirect evidence of their existence, or, if evidence is lacking, we can simply have faith in their contribution to the student's development.

Under this heading we can include improvement in the ability to organize and absorb information and an increase in the rate at which the material can be assimilated. At the same time there can be an improvement in the student's confidence in his own ability to learn similar material effectively. We can also hope for an improvement in the ability to solve problems for which the method of solution has not been laid out specifically in advance. And we can propose that such developments will apply, at least in some degree, to the ability to face and attack problems in distantly related subjects and to make intelligent and defensible decisions about the problems encountered in the routine of ordinary living.

This last proposal brings up the controversial question of transference, which some educational authorities have asserted does not exist. They say that exposure to one course of study does not improve the ability to assimilate other subjects. What they probably mean is that the use of available methods of examination fails to show unequivocally that there is a transference of ability. From this conclusion they go on to the negative conclusion that there is no transference.

I find it necessary to disagree and to assume that their result is fallacious because their methods of testing are not adequate. If they say that the educational values derived from our system are mainly restricted to the subjects studied, they must mean that formal education as a preparation for life is dismally inefficient if not an absolute failure. The total spread of human knowledge grows broader every day, so that the fraction of it to which an individual can be exposed in four or even six or eight years in college appears smaller and smaller in relation to the whole. There is no possibility of exposing him to training which will have a direct bearing on more than a secondary fraction of the situations which he will have to face in his personal or professional life. If we are to support our educational system as defensible, we are forced to believe that training in a limited field can help to develop the mental acuity and wisdom required for unrelated situations. It is fortunate that, in spite of a scarcity of direct evidence, there are powerful indirect arguments supporting this point of view.

We can now venture to summarize what the student can be expected to achieve in his first organic chemistry course. He will retain very little of the direct content of facts and theory for any extended period of time, but when this information is brought up again in a later chemistry or pharmacy course, he will recall or reassimilate it with ease and rapidity. He is clearly far better prepared to attempt the next course in organic chemistry, pharmacy, biochemistry, or chemical engineering, and we can hope that his ability to cope with a course in philosophy, economics, history, or even Russian has been improved. He has had an experience in organizing and learning, at least temporarily, an extensive amount of material, and we can confidently expect that his capacity and speed of assimilation have been improved, even in apparently unrelated subjects. He has been faced with the problem of studying an instructor in terms of the kind of thing the instructor emphasizes and the kind of question he is likely to ask on examinations. His success in figuring out the instructor has broadened his experience in a direction which may be useful in social contacts and even in business deals. Finally, he has been encouraged to think his way out of situations which call for combining items from different parts of his store of information. We hope that he can transfer some of this ability and experience to situations involving unrelated subject matter.

With this necessarily somewhat indefinite summary of achievement before us, we can now try to see where the pharmacy student fits into the program. Specific facts do not appear to be very important since he may lose most of them quickly, but when faced in a later pharmacy course with one of these facts which he has already learned and forgotten, he should relearn it at sight. He may lose this fact again and have to learn it a third time when he becomes a retail pharmacist or pharmaceutical chemist. New facts not given in the first course should be learned with ease in the later pharmacy course or in professional work. Important permanent values should have been acquired which will show themselves in an improved capacity for further learning and for solving problems of all kinds.

In these terms the particular content of the course is of secondary importance, provided that it is extensive and representative. The more important point is that he shall have successfully solved the problem of taking and passing a course of the particular kind which a competent instructor chooses to present.

From this point of view the course best suited for training chemists will not be much different from the one most suitable for pharmacists or chemical engineers, since the major intangible values to be derived are independent of the field of specialization and are not heavily dependent upon the exact outline or length of the course.

In conclusion, it can be stated (1) that the particular

arrangement of organic chemistry courses now offered at the University of Michigan grew out of the need for simplicity and flexibility of organization in our role as a service department, (2) that the flexibility of organization appears to be reflecting itself in a flexibility of selection of material for the course, and (3) that we are firmly committed to the opinion that the exposure of students in several fields of specialization to the same beginning course is an entirely effective and satisfactory policy.

SCOPE, OBJECTIVES, AND APPLICATIONS OF A COURSE IN BIOCHEMISTRY

Howard B. Lewis

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In 1946, the writer, speaking before the Conference of Teachers of Chemistry (1), discussed the place and future of biochemistry in the pharmacy curriculum. At that time, he expressed the conviction that the "inclusion of biochemistry as a required subject would be necessary within ten years unless the trends in professional pharmacy and in medicine changed materially" and also said that "it is our duty to see that our graduates are properly equipped to meet the challenge of a medicine that is becoming increasingly more biochemical." This conviction has not been altered in the years which have passed since that time.

The presentation of 1946 was based primarily on a survey of courses in biological chemistry given in the colleges of pharmacy of the United States, made at the request of the Syllabus Committee. Little can be added today except to emphasize the point of view expressed then. The problem of the relation of biological chemistry to pharmacy and its place in pharmaceutical education is essentially unchanged.

It was the almost unanimous opinion of those with whom the problem was taken up that some formal training in biological chemistry was desirable for students in pharmacy. The chief objection to the inclusion of biological chemistry as a required subject in the curriculum of pharmacy was a matter of scheduling. "The curriculum is too full already," "it is impossible to introduce more allied sciences without subjecting pharmacy to a secondary level," "too many basic or tool subjects now" and "would make elimination of essential courses in pharmaceutical chemistry necessary" were most typical of the objections that were raised at that time. With the broadening of the curriculum in pharmacy, these objections would seem to be no longer valid. If, as seems probable, the period of training of pharmacists is increased in the near future from 4 to 5 years, surely time for a subject almost universally considered as desirable can be found without excluding other essential aspects of pharmacy.

1. Relation of Biological Chemistry to Other Professional and Preprofessional Subjects

Biological chemistry is the chemistry of the living organism and is dependent upon a clear appreciation of the basic facts of chemistry, inorganic, organic, and physical, for its understanding. The student of pharmacy should come to the study of biological chemistry with a better knowledge of this background in pure chemistry than do most of the students of medicine with whom in many cases he is associated in his work. Biological chemistry, in turn, represents the chemical side of physiology and is of equal importance with physical physiology (perhaps to become biophysics in the next generation) in the development of modern medicine, to which pharmacy is so closely tied. Pharmacology, whose rapid development and diversification is one of the outstanding aspects of preclinical medical science, is in turn dependent on physiology and biological chemistry for its chief tools.

Since pharmacy is concerned with the preparation and dispensing of drugs, it follows that pharmacology, as well as physiology and biological chemistry, is fundamental for good pharmacy. In recent years we have seen pharmacology and physiology introduced as required subjects in the pharmaceutical curriculum. Why has biological chemistry been left outside of the circle?

The thesis of the relation of biological chemistry (chemical physiology, if you will) to pharmacy hardly needs any defense. A few illustrations will suffice to show the relationship suggested. How can the use of the antihistamine drugs be understood without a knowledge of histamine, its chemistry, its biological origin and function as well as its pharmacology? The use of antihistamines in therapy also involves an understanding of the theory of antimetabolites, a recently introduced aspect of biological chemistry and physiology. Biological antagonism, antivitamins, antihormones, and antimetabolites are all aspects of biological chemistry as yet little understood, which are certain to become of fundamental significance in the near future. For understanding of the varied developments, which can be confidently predicted, a clear understanding of the normal cell and tissue and its chemistry is essential.

Who would have predicted that the substitution of bivalent sulfur for oxygen in a heterocyclic ring of natural occurrence might revolutionize therapeutic treatment of a common disease? The chief component of the cell nucleus, which is also important in protoplasm, is nucleoprotein and its cleavage product, nucleic acid. Certain nucleic acids, of exceedingly complex structure, yield on hydrolysis two pyrimidine bases, one of which is uracil, 2,4-diketopyrimidine. The replacement of the oxygen in the two position by sulfur results in a powerful drug

which influences thyroid function. In an individual in whom hyperfunction of the thyroid occurs, a common occurrence, 2-thiouracil and related thiopyrimidines depress the thyroid function in a very useful therapeutic procedure. Hyperthyroidism is known to be associated with an overproduction of the thyroid hormone, an iodine-containing derivative of the benzene ring, of the naturally-occurring amino acid, tyrosine. Presumably the depression of thyroid function by the thiouracils resulted from a decreased synthesis of the thyroid hormone. The proof came by the use of a new tool in biochemical, in fact in general biological, research, the isotopes, in this case radioactive iodine, I^{131}. Thus it was possible to prove that thiouracil did not influence the uptake of iodine by the thyroid gland but that by its presence it prevented the incorporation of the iodine ion into the benzene ring, which of necessity must precede the synthesis of the thyroxine, one of the thyroid hormones.

This illustrates one of the many developments of the use of isotopes in the solution of problems of biological importance.

2. Content of Course

From what has already been said it will, I hope, be evident that it is the conviction of the speaker that a strong course in the fundamentals of biochemistry should be available to the student in pharmacy. Medicine is becoming more chemical each year and, if the student of pharmacy of tomorrow is to speak the language of the physician who comes to him for help in matters biochemical, he must have a knowledge of the fundamentals. The writer believes that in our better schools a course of similar content to that available to the student of medicine or dentistry should be available to the pharmacy student. This should include the basic facts concerning the organic chemistry of the major tissue components, the activity of enzymes, digestion, respiration and circulation, kidney function, and basal metabolism. A study of hormones, vitamins, and biological antagonism should be included. Some discussion of functional tests, tests for gastric, hepatic, or kidney function should be given. All these are presented to the medical student and should be made equally available to the student in pharmacy.

3. Lecture or Laboratory, Which?

This is a difficult problem. With a program already so full of practical work, can space be found for practical as well as theoretical work in biological chemistry? In recent years laboratory work in this subject has become increasingly quantitative in character. The old "test tube-sink" qualitative experiments are being replaced by quantitative experiments. The student is given the opportunity to familiarize himself with new tools of analytical chemistry. The analytical chemistry of biochemistry is micro or even micro-micro in character. Colorimetry, mainly photoelectric, spectrophotometry, ultraviolet spectroscopy, chromatography, and the use of infrared are all new tools, many of which cannot be added to the fundamentals of quantitative analysis.

It is the belief of the writer that a laboratory course in biological chemistry is as essential as is a lecture course and only by the combination of the two will the student be given the necessary information to be used subsequently in physiology, pharmacology, microbiology, and related preprofessional and professional courses. It may be difficult to find a place in the crowded curriculum of pharmacy for such a course, but it should be possible, particularly if a five-year plan is adopted.

In some instances, it may well be that facilities (staff or laboratory and perhaps time) are not available for the organization of a broad course in biological chemistry, given by a man with the proper specialized training in this subject. Half a loaf is better than none, particularly if the half is excellent. If it is not possible to offer laboratory instruction, a comprehensive lecture course could and should be made available.

A word of caution may serve to emphasize the conviction which the writer has held for many years. The catalogues of some schools have shown that there has been offered a "practical" (laboratory) course in urine analysis, accompanied in many cases by some training in hematology and clinical blood analysis. This work frequently is misnamed "biochemistry" and is offered essentially as a "bread and butter" course, justified by an alleged opportunity for pharmacists to offer to physicians the services of a clinical laboratory. This may have been true twenty-five years ago, but conditions have changed materially and such opportunities are greatly restricted and further restrictions may be expected to be imposed in the near future. Currently such work in hospitals or accredited laboratories must be under the supervision of a physician and is performed by a "medical technologist," whose training is supervised closely and is highly specialized. The pharmacy student without more training than is afforded by such superficial courses as those mentioned can hardly qualify. These courses can well disappear promptly from our curriculums to be replaced by courses of broader background and content.

4. Hours of Credit

While credit must vary according to the opportunities available in each school, it would seem that adequate training cannot be obtained by less than three lecture hours per week for a sixteen-week semester and two laboratory periods of three hours each weekly. This is somewhat less than the work offered in our standard medical schools and must be

regarded as minimal. The laboratory hours are definitely less, but it is believed that, with the superior background in chemistry available to the student of pharmacy, the smaller number of hours may be used with greater efficiency than in the longer medical course.

It is believed that wherever possible, however, the work in medical biochemistry should be offered for students of pharmacy. The co-operation and the friendship between students of pharmacy and students of the other health sciences are mutually advantageous and make for better understanding. In the survey already referred to, one dean has commented: "Our students are taking their work with young medical students and make friendships, which carry over into their entire professional lives."

5. Texts - Instruction

No text of biochemistry is completely satisfactory for students in the various health sciences. Many of the available texts are too detailed to be useful to students on a level lower than that of graduate students. Others contain material supposed to be suitable for students in agriculture or home economics. There is no adequate text written with the needs of the student of pharmacy in mind. Perhaps the answer may be found in a text written by a man with basic training in pharmacy, with sound graduate or professional training in biological chemistry, who expects to return, or may have already returned, to pharmacy as a teacher. Such a background should afford us an excellent text in biological chemistry for use in colleges of pharmacy.

This suggests a related problem, the training of those who are to undertake instruction in biological chemistry, particularly in those schools in which geographical relationships do not permit the use of the facilities of a medical school. It is believed that this constitutes a real challenge to younger graduates of pharmacy, of high scholastic standing. If the broad background of pharmaceutical training were used as a basis of graduate work in an approved department of biological chemistry, an important field would be open to men thus trained, when the subject of biological chemistry assumes an important place in the curriculum in pharmacy, as the writer believes must be in the near future. Many graduate departments of pharmacology are now training young pharmacists to return to educational work in pharmacy as teachers of pharmacology and such a trend, although not yet apparent in biological chemistry, will be seen, I am confident, in the near future. One can envisage, even in those schools in which biological chemistry is taught outside of the college of pharmacy, the use of pharmacy graduates with graduate training (or degrees) in biological chemistry as teachers in these departments, perhaps holding joint appointments in the schools of medicine and pharmacy, for example. Such instruction would enable the medical school to function more efficiently in the training of pharmacy students, and the association of these men with other members in biochemistry would be mutually advantageous.

One word of warning. The salaries available to men properly qualified in biochemistry have increased significantly in the last few years, and there is currently a shortage of such men who are interested in teaching. If men complete the training outlined above and schools of pharmacy desire to attract these men to return to the faculties of pharmacy, due regard must be paid to the "market"; otherwise these qualified teachers will go elsewhere, to industry or research. In medical schools, teaching loads are not heavy and encouragement in and opportunities for research are offered. Such inducements must be given to our young men if they are to remain in schools of pharmacy for the development of strong educational and research programs in biochemistry. The problems of pharmacy are as broad as those in any of the health sciences; surely a place can be found for the well-trained biochemist to the advantage of both the school and the individual concerned.

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INDUSTRY'S REQUIREMENTS FOR PHARMACEUTICAL RESEARCH PERSONNEL

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I realize that this is a seminar of teachers in pharmaceutical chemistry devoted almost exclusively to discussions for improving the teaching of chemistry in the schools of pharmacy. I am happy to attend this seminar and to know of the efforts being made by you -- the chemistry teachers of the pharmacy schools -- to examine your methods of teaching and to keep chemistry alive and vigorous. As the faculty of the schools of pharmacy, you are cognizant of the other functions of the pharmacy schools and you should know that American pharmacy is facing a real problem because of the insufficiency of personnel trained in pharmacy itself in contrast to that trained in chemistry, pharmacology, bacteriology, etc.

I stand before you as one who has been trained in pharmacy and in organic chemistry and who has devoted a fair amount of effort to research in pharmaceutical chemistry. In many respects, I am one of you and, as such, I feel that you will understand the importance of what I have to say. I want you to know, however, that my presentation is made with deep humility, since this group, the leaders in pharmacy education, recognizes the deficiencies and is constantly endeavoring to correct them.

The thesis of my paper is concerned with the need for re-emphasizing in our pharmacy schools pharmacy defined as the science and art of preparing, preserving, compounding, and dispensing medicines. Pharmacy, as just defined, must be one of the oldest arts known to man and its development into a science forms a fascinating chapter in the history of modern sciences. The profession has a great heritage, and the pharmacist today can be rightfully proud of pharmacy's contributions to the treatment of disease. Not only has pharmacy played an important role in man's everlasting battle against disease, but it has also begotten great scientists in related fields. In many respects pharmacy may be considered as the mother of some of the related fields of science. The contributions of Scheele, Pelletier, Liebig, Wohler, Sertuerner, and literally scores of others to chemistry, attest the importance that pharmacy has played in an allied science. Other scientific fields such as pharmacology, botany, mycology, and bacteriology have also been profoundly influenced by the men with pharmaceutical background.

Although the allied sciences such as chemistry, pharmacology, and botany were stimulated by pharmacy, they have been separated from it and have grown enormously in size and scope. Each field of science is a major segment of the modern university, no longer dominated by the teachers of the schools of pharmacy. During the past twenty-five years, these fields of science have brought forth countless new fundamental advancements, many of which are responsible for our present way of life. In recognizing these scientific developments, we may ask ourselves several questions.

1. Has pharmacy as a science kept pace with other fields of science?
2. Have the schools of pharmacy stressed the development of the science of pharmacy?
3. Is research in pharmacy a basic function of the schools of pharmacy? In looking over the publications of the Scientific Edition of the Journal of the American Pharmaceutical Association for the first six months of this year, one finds only 15 papers out of 105 devoted to pharmacy. Of the remainder 33 are concerned with pharmacology, bacteriology and pharmacognosy; 26 are devoted to analytical methods; 26 to phytochemistry and organic syntheses; and 5 to miscellaneous subjects. Of the 15 pharmacy papers only 8 are contributions from the schools of pharmacy.

Do these data imply that pharmacy is not receiving the research emphasis that it deserves?

Although it is true that research programs carried out in the schools of pharmacy in the allied sciences (as chemistry, pharmacology, and bacteriology) contribute in varying degrees to the over-all development of pharmacy, there still remains the fact that the efforts in the allied fields overshadow those in pharmacy itself.

During the past thirty years the role of the pharmacy in compounding medicinals has undergone a drastic change. With the rapid growth of pharmaceutical manufacturers, the community pharmacy has lost the greater share of formulation operations. In addition, basic research carried out in the laboratories of the pharmaceutical manufacturer has created a host of new and better agents for the control of disease. We need not discuss the reasons for this "industrial revolution" in pharmacy or the merits and disadvantages resulting from this change. We all realize that a fundamental change has occurred. The scientific practice of pharmacy has, in the main, shifted from the community drugstore to

industry.

This change has created new problems and a greater challenge. With the creation of industrial pharmacy, new standards and procedures were needed. With every new drug born out of research for the treatment of disease, new problems of compounding arise. Without proper formulations, drugs of promise often fail in their practical application in the treatment of patients. The antibiotics, penicillin, and streptomycin would have had limited application had not the art of formulating sterile products been developed. Insulin therapy would be a continual hardship had not a form with prolonged action been developed. If the lyophylization procedure for blood plasma had not been available, many more lives would have been lost during the last war.

These examples are only a few of the many which can be cited. They point out the increasingly important part that pharmacy plays in modern medicine. Let us examine a few of the developments in pharmacy which have taken place during the past twenty years. Foremost in my mind are the antibiotics, penicillin, and streptomycin.

When penicillin was first recognized by Florey and Chain (1940) as an agent for the control of infectious diseases, the need for a practical formulation became evident. It was known that penicillin was unstable in aqueous solutions and toward dry heat, so consequently the problems of administering this drug to patients were serious. Since the drug has low oral activity, the need for administration of sterile product was evident. It was also known that penicillin preparations were frequently contaminated by pyrogens and that control of such dangerous impurities was necessary. All these problems were difficult to solve as many of us who have taken part in the hectic activities in the early developments can testify. These were new problems and we had little to draw on from the science of pharmacy.

In spite of the accomplishments of producing usable and effective products, penicillin still had many shortcomings. Its instability and rapid excretion from the body necessitated treatment by injection every four to six hours around the clock. The need for a repository, prolonged acting form was evident and this need led to procaine penicillin. Even this water insoluble form required considerable study and development since particle size and type of crystals affected the prolongation of action. In addition, problems of suspending insoluble procaine penicillin had to be solved. On top of all this, the final formulations had to be sterile! Today, sterile aqueous suspensions of procaine penicillin stable at room temperature are available to the physician and are ready for use without any preparations by the physician or nurse. The research and development of this product form a fascinating chapter in the history of modern pharmacy.

Streptomycin and dihydrostreptomycin also had their share of pharmacy problems, although the experiences in the penicillin field lessened the difficulties. New techniques such as sterile crystallization had to be mastered. The development of stable solutions of streptomycin and dihydrostreptomycin sulfate is an accomplishment worth noting.

In the preparation of sterile solutions the problem of pyrogens has been severe. Today, we understand the nature of pyrogens and how to control them.

Little consideration has been given in the past to the need for sterile ophthalmic preparations. Formulations for ophthalmic use, such as solutions, suspensions, and ointments are generally not prepared under sterile conditions and are dispensed as non-sterile products. This condition has been recognized in the past and efforts to correct this by the use of bacteriostatic agents have been made. As some of you know, a movement to require sterility for all ophthalmic preparations is currently under way. No one can dispute the wisdom of this move, but many can question why sterile ophthalmic preparations had not become available sooner. Who should have recognized the problem, the pharmacist, the physician, or the Food and Drug Administration?

One can rightfully ask whether the schools of pharmacy can take a greater part in the development of the science of pharmacy. Can the school of pharmacy be expected to compete with the modern pharmaceutical manufacturer with its manpower and facilities? I believe in the affirmative. In the universities departments of chemistry, physics, engineering, etc. compete successfully with the industrial research organizations. We still look to the university science departments for the fundamental advances without which industry would progress at a very slow pace. University research and industrial research actually do not compete but rather complement each other.

One of the basic differences between industrial and university research is the objective. Industrial research as a whole must eventually suggest or lead to a practical end and because of this restriction, industry does not have the means or the patience to delve in fundamentals. Once a task is achieved, it is difficult to return to a study of the basic underlying principles. This the university can perform without restrictions and in doing so adds to a better understanding of the science. Another important difference between industry and the university with respect to research and development is the policy of publication. To a significant extent, discoveries and the resulting "know-how" are considered by industry as capital and are not published. This is particularly true in the field of pharmacy. Very little has been published in our scientific journals on the methods, techniques, and pharmaceutical properties of the antibiotics, yet these developments represent an important advancement in the science of pharmacy. Very few impartial and cold scientific appraisals of penicillin formulations have been reported. Indeed, our literature is woefully lacking in these respects.

The schools of pharmacy must fill the gaps created by industry and, in fact, broaden their scope of research activities. They should recapture the lead in developing basic methods. There are still problems in penicillin therapy that need resolution. A better understanding of the relation of particle size to prolongation of effectiveness needs an impartial scientific appraisal. The relationship between blood levels and effectiveness is now questioned. There is still much to be done toward the development of better dosage forms.

What I have said for penicillin is desirable for all other new drugs whether they are sole properties of one company or whether they have no patent restrictions. Even if an important compound, such as one of the broad spectra antibiotics as aureomycin, chloromycetin, and terramycin, is restricted by patents, it should be the subject of pharmaceutical research and the data should be published in scientific journals. This is the only way to assure progress in pharmacy.

Let us examine some of the fields of pharmacy which need greater emphasis.

1. Ophthalmic preparations -- the development of sterile dosage forms including ointments and including intraocular parenterals. The development of techniques and methods for the preparation of various forms is only part of the story. What can be done to assure sterility of the product while it is being used by the physician or the patient?
2. Fundamental studies of colloidal phenomena as applied to pharmacy. We need to improve our understanding of thixotropy, surfactants, and suspending agents. The developments in this field of surface active chemistry have been great and they have found application in a variety of products. A knowledge of colloidal behavior has been important in the development of synthetic rubber. Surface active agents are integral parts of detergents. Some surface active agents have been introduced into pharmacy, as the Tweens and the Tritons. Suspending agents as carboxymethyl cellulose and the alginates are commonly used in pharmacy today.
3. There is a great need for a better understanding of absorption of drugs through the skin, mucous membranes, lungs (aerosols), etc. What part does the vehicle play in absorption? What is known about the relation between ointment bases and the effectiveness of the drug in an ointment? Recently, we have had occasion to study the penetration of cortisone through the skin of an animal when applied in the form of an ointment. We found, as one may suspect, that the absorption varied greatly depending on the composition of the ointment base. It is obvious that a drug in the form of an ointment may fail in its application unless an understanding of this important relationship is recognized and understood.
4. There are many reasons why one would want to convert a soluble drug to an insoluble form and to solubilize insoluble drugs. Methods for accomplishing such transformations need to be developed.
5. Intravenous fat soluble emulsions are becoming increasingly important. Emulsions of vitamin K_1 and fat emulsions themselves, needed for nutrition in many instances, are examples of this class of preparations. How small must fat particles be for safe administration? How can one prepare stable, sterile, injectible emulsions free from pyrogens with particle sizes below 1 micron in diameter?
6. With the advent of tools for reducing particle sizes of solids, we should know more about the effectiveness of insoluble drugs as a function of particle size. Ointments, injectible suspensions, and even oral preparations of insoluble drugs should be evaluated clinically, using particle sizes of even 1 micron or less.
7. More emphasis must be placed on a study of incompatibilities of the modern drugs and of methods for overcoming incompatibilities. This has always been an important part of pharmacy and pharmacy libraries have many books dealing with this subject. Most of these books deal with incompatibilities of the older drugs. Much less has been published about the important drugs of today.

Thus far, I have discussed what pharmacy as a science must face in light of more recent advances in the medicinals. Now I should like to turn to the important problem: What is required of the pharmacist today who wants to practice pharmacy as a science?

As we all know, the greater part of the students of schools of pharmacy design their careers with the view of the community drugstore. Although this function of the schools of pharmacy must be maintained, it is equally important to train men who will make a career in the science of pharmacy. The schools of pharmacy have not been as successful as the other scientific schools in stimulating students to prepare for a scientific career. Can this be overcome in part by stressing the past and present importance of this aspect of pharmacy from the first day that a student matriculates?

A basic requirement for research and development in industrial pharmacy is the scientific attitude. Along with this is the urge and desire to devote one's life to the science of pharmacy. These qualifications are generally the result of a stimulation from the relationship of the teacher and student. This stimulation is strongest when the teacher is a scientist with an active research program. As I look back on my own experiences as an undergraduate student, perhaps the greatest stimulation I received was the opportunity to carry out a senior research program on a subject never previously investigated. Admittedly,

it was a small project requiring only six hours per week of work and the results were few. It brought me in direct contact, however, with an able scientist and teacher.

The training of scientists in pharmacy must begin in the undergraduate schools. Since there is a limit to what can be covered in four years, it is obvious that the schools of pharmacy have a difficult task. The necessity of providing sufficient course work for a student to pass State Board examinations does not make the task easier. Perhaps this is where an attack of the problem should begin. Do the State Board examiners recognize the "industrial revolution" in pharmacy? We know that prescriptions of today differ radically from those of twenty years ago. Do the pharmacy dispensing courses recognize this change and have they made changes in light of the new drugs? How many dispensing courses include formulations of the antibiotics, ACTH, thyroxine, cortisone, vitamin B_{12}, p-aminosalicylic acid?

Aside from bringing courses up to date, it seems to me that the schools of pharmacy (possibly together with the State Boards) should further reexamine the courses of study in light of modern trends and developments and modify their curriculums accordingly. Some courses should be deemphasized or deleted in favor of the need for newer knowledge. Physical chemistry as applied to pharmacy should receive greater stress, particularly for those who intend to carry out research in pharmacy. Newer and important techniques, such as sterile processing, should be included in pharmacy courses. Possibly, schools of pharmacy should have more optional courses, i.e. a minimum basic curriculum for everyone to assure sufficient background to pass State Board examinations and optional courses depending on the career a student chooses.

It is obvious that a more complete training can be obtained only by graduate study. I believe that those who choose pharmacy as a scientific career should place greater emphasis on the following subjects:

1. Physical chemical concepts in pharmaceutical problems: (1) chemical kinetics to study and understand instability of compounds, (2) chemical equilibria to alter solubility of therapeutic agents (use of procaine hydrochloride with procaine penicillin), (3) phase rule as applied to changes in crystal form in pharmaceuticals, and (4) more intensive study of physical properties of solutions -- ionization, pH, buffers, solubility of solutes, isotonicity, etc.
2. Less emphasis on organic synthesis and more on organic reactions themselves.
3. More bacteriology, some biochemistry and some pharmacology.
4. Courses in pharmaceutical manufacturing.
   a) Operation experience of pharmaceutical and processing equipment (including aseptic operations). Understanding and appreciation of the process equipment required for large-scale operations are essential.
   b) An understanding of industrial materials used in the construction of large-scale equipment (rubber, glass, metals, synthetics, plastics, porcelain, etc.) as they affect formulation processes and the products themselves.
5. Study of chemistry and properties of new raw materials. This is a continually changing field because of the constant developments in the chemical industry.
   a) Stabilizers
   b) Antioxidants
   c) Dispersants and surfactants
   d) Suspending agents
   e) New solvents, ointment bases
   f) New flavoring agents
   g) Preservatives
6. An understanding of modern instrumentation as applied to pharmacy, such as X-ray, infra-red, ultraviolet, viscosity, surface tension, etc.
7. A better understanding of the principles of analytical chemistry as applied to study of stability and control of pharmaceuticals.
8. A better understanding of and acquaintance with the scientific literature and encouragement of the habit of reading current scientific publications are essential for the prosecution of research and development in pharmacy.

In our thinking of the place of pharmacy, it should be noted that today our pharmaceutical industry is the most productive in the world, virtually independent of foreign drug sources. The total sales of medicinals in 1951 were in excess of $1,200,000,000. Today over 60 per cent of these total sales are accounted for by medicinals not known ten years ago; 75 per cent of these sales by medicinals unknown fifteen years ago. These figures demonstrate the need for research in pharmacy and pose a challenge which must be met if pharmacy as a science is to survive.

THE OBJECTIVES, PREREQUISITES AND SCOPE OF ORGANIC PHARMACEUTICAL CHEMISTRY

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Organic pharmaceutical chemistry comprises a knowledge of the sources, methods of procurement or synthesis, physical and chemical properties, methods of identification and standardization, and uses of organic chemicals used in clinical and experimental medicine and in the fabrication of dosage forms of these. The importance of such knowledge is attested by the fact that 87 per cent of the items tentatively admitted to U.S.P.XV are organic chemicals or preparations of these. The list may be further subclassified in that 48 per cent (392 items) of the total admissions are synthetic drugs or preparations of them and 39 per cent (318 items) are of natural origin. They range in complexity from the relatively simple hydrocarbons to the amazingly complex heterocyclics and proteins. Many of the known types are represented as well as most of the functional groups. A majority of these substances are quantitatively assayed and all of them have some descriptive physical or chemical tests for identity and the absence of impurities.

Aside from the 710 items of organic nature found in the Pharmacopeia, uncounted others are described in the National Formulary and New and Non-Official Remedies. We are all aware of the huge numbers of new, experimental organic chemicals that are annually turned out by the academic and industrial laboratories of the world. Even though only a tiny fraction of this production reaches the developmental and exploitation stage, the number of clinically tested drugs increases at a swift pace.

Among the over-all objectives of pharmaceutical education, it has been stated that the graduate should be (1) reasonably competent to begin the practice of pharmacy at the level of a professional man and (2) capable of keeping abreast of the growing edge of professional knowledge. In view of the preponderance of organic drugs with which the pharmacist deals, it seems obvious that the subject matter of organic pharmaceutical chemistry should occupy an important place in his education. This would be true even if undergraduate pharmaceutical education were aimed solely at producing competent pharmacists. On the assumption that a small but significant and important number of undergraduates are to become the teachers and investigators of the future, it becomes important that organic pharmaceutical chemistry be taught not only from a rigorously scientific viewpoint but also with a creative, if not to say visionary, spirit on the part of the teacher.

Before one speaks of prerequisites for instruction in any course, it is usually useful to set down the goals which one hopes to achieve as a result of the instruction. It might be less controversial if the statement of objectives to be achieved were couched in the general terms which were used in the introduction. Indeed, each of you when faced with the necessity of formulating a statement of objectives for the courses which you teach will state them in your own words. This paper cannot and does not pretend to offer you a statement of objectives which will meet with your complete approval. The statements which follow are what I hope the students in the courses in organic pharmaceutical chemistry which I teach (or have taught in the past) will achieve. The subject matter selected and the method of presentation are designed to provide students with the opportunity and the inspiration to achieve these objectives.

For administrative reasons, instruction in organic pharmaceutical chemistry in our college is segmented into several courses, each with a descriptive title such as (a) Drug Assay (4 quarter hours), (b) Chemistry of Synthetic Drugs (4 quarter hours), (c) Chemistry of Natural Products (4 quarter hours) and (d) Synthesis of Drugs (5 quarter hours).

Instruction in organic pharmaceutical chemistry should provide the student with:

1. Familiarity with the sources, general method of isolation, physical and chemical properties, and pharmacologic and pharmaceutical uses of naturally occurring substances used in medicine and pharmacy
2. Awareness of the methods of isolation, functional group identification, structural deduction, and verification for naturally occurring potent drugs and the impact that such knowledge has had upon synthetic drug invention
3. Awareness of systems of drug classification based upon (a) chemical structure (b) therapeutic use (c) physiologic origin
4. Facility in reading chemical nomenclature of substances used as drugs
5. Ability to correlate chemical names, structural formulas, and chemical properties as illustrated by names and formulas
6. Awareness of the manner of thought by which new products are conceived by research workers in pharmaceutical chemistry
7. Awareness of the necessary steps from mental

conception to production and distribution of a new drug substance
8. Awareness of the possible effect of homology, isomerism, optical activity, isoterism, resonance and the replacement of elements upon the physical, chemical, and pharmacologic properties of drug substances
9. An appreciation of the importance of analytical chemistry to the isolation, identification, degradation, structural verification, and quality control of both natural and synthetic drugs
10. The acquisition of some training in the use of analytical methods and tools for the examination and standardization of drugs
11. The acquisition of some training in organic synthetic reactions of a sequential nature

Prerequisites

The list of prerequisite courses for organic pharmaceutical chemistry has been presented many times by many teachers. It needs only to be restated to be recalled to your mind. Nearly every teacher of organic pharmaceutical chemistry can agree upon the following sequence as representing an adequate if not optimal amount of study.

1. General Chemistry and Qualitative Analysis (10 semester hours)
2. Quantitative Analysis (4 semester hours)
3. Organic Chemistry (10 semester hours)
4. Physical Chemistry (4 semester hours)

At this point, part of the applied sequence may be presented, such as:

5. Drug Assay (4 semester hours)

Coincident or subsequent to the above course, is suggested:

6. Biological Chemistry (6 semester hours)

In the last professional year should be presented:

7. The Chemistry and Pharmacy of Medicinals (6 semester hours)

It will be noted that some of the prerequisite courses should have prerequisites of their own, e.g., physical chemistry should be based on two years of college mathematics and one year of physics, and physics should be preceded by one year of college mathematics.

Biological chemistry should be preceded by a graded sequence of biological courses up to or through human physiology, and the last two courses in applied chemistry may well follow or accompany some pharmacology.

The entire scheme may be graphically presented by the slide.

Scope

In outlining the scope of the subject matter to be presented in the applied courses a presentation to this audience need not be too specific. Each of you has the training and independence of thought which will guide you in your own classes. I wish only to present my personal concept of the way in which these courses may be organized to present interesting and stimulating ideas.

Drug Assay

This course should include a number of the general analytical procedures used to determine the quantitative composition of the substances described in the official books. It will be impossible to carry out all of the general assays but a selection can be made of those which illustrate principles and which require the exercise of techniques not previously used in the beginning course in inorganic quantitative analysis.

In the first course in drug assay, the student should acquire (1) some familiarity with analytical techniques for the determination of constituents of drugs which do not react ionically; (2) an appreciation of the reasons for requiring a quantitative assay in the case of natural as well as synthetic drugs; (3) knowledge regarding the possible diluents or impurities which may be encountered and how these may affect the results; (4) an introduction to physical and instrumental methods of analysis.

In the didactic portion of the instruction, an attempt should be made to bring to the attention of the class other applications of the method used and other methods of evaluating the sample assayed.

A sample list of experiments which illustrate some interesting applications of methodology could be:

1. Determination of formaldehyde
2. Determination of alcohol in one of the following:
   a) a mixture containing no other volatile component except water
   b) a mixture containing a volatile component such as a volatile oil
   c) a mixture containing methyl alcohol
3. Determination of phenol in liquefied phenol
4. Assay of an alkaloidal drug
5. Determination of specific rotation of a sugar
6. Determination of refractive index of an oil or a sugar solution
7. Determination of several constants of a fixed oil (saponification value, iodine value, specific gravity)
8. Assay of an essential oil by cassia flask method
9. Assay of an alkali salt of salicylic acid
10. Chemical assay of a vitamin such as:
    a) Thiamine (Thiochrome method)
    b) Riboflavin (Fluorometric method)
    c) Ascorbic acid (Titration method)
    d) Niacin (Colorimetric method)

The Chemistry and Pharmacy of Medicinals

The subject matter of these courses includes a discussion of the nomenclature, composition, sources sources, methods of synthesis or isolation, chemical and physical properties, and therapeutic uses of organic drugs used in modern medicine.

Later today, we will hear presentations of two different schemes of classification for the presentation of this material so I shall only indicate that in my teaching I have adopted a classification of the synthetic drugs based upon pharmacological use.

In discussing synthetic drugs, I find it helpful to include naturally occurring drugs whenever, as is frequently the case, the prototype of a pharmacological class is a natural substance.

I have grouped another list of compounds under the title of "The Chemistry of Natural Products." The classification system used with this group is not primarily pharmacological, but a combination of chemical and physiological with pharmacological subclassification.

The synthetic drug section of the material, it seems to me, should be presented so that the student may learn:

1. To translate the chemical nomenclature given on the trade package into structural formulas.
2. To recognise types of chemical compounds from their structure.
3. To predict in a general way chemical and physical properties from structure.
4. Those physical and chemical properties which are likely to affect the solubility, stability, and compatibility of the compounds.
5. The effect of variations in structure on physical, chemical, and pharmacologic properties.
6. The methods of synthesis of the various types of compounds.
7. The trend of recent research in the field.

In the section devoted to natural products, the subject matter should be presented so that the student will learn:

1. The source of the product.
2. A method of isolation.
3. The physical and chemical properties.
4. To recognize the structural formula.
5. The pharmacological and/or the technological uses of the compound.
6. The effect of alteration in structure upon pharmacological properties.
7. The effect of stereoisomerism upon pharmacological properties.

The presentation of these two courses should require two semesters of lecture presentation of not less than three hours per week. It would be helpful if the instruction could include some laboratory work to fix the pharmaceutical aspects of the material more firmly in the students' minds. If this is possible under a co-operative agreement with the teachers of pharmaceutical technology, it will result in a significant increase in teaching value.

A course in the synthesis of drugs consisting of laboratory work and semi-independent reading, I believe, has another sort of value in the teaching of organic pharmaceutical chemistry. In such a course, the students are permitted to choose from a list of organic drugs those toward which they have developed some curiosity. They are directed by the teacher to probable sources of information regarding the method of synthesis and are expected to abstract from these sources a set of experimental directions which they think will yield the desired product. This is written up and presented to the teacher for criticism. If approved, permission is granted to proceed with the synthesis.

As a result of this experience, the student should acquire:

1. Familiarity with the sources of chemical information
2. Increased knowledge of the compounds synthesized
3. Increased skill in chemical synthesis
4. An introduction to independent study
5. Either a stimulus to graduate study in the field or a definite opinion that it would not be a pleasant experience

There seems to be no reason why this paper should present more details such as the classes of drugs or the individual drugs to be presented. There are numerous books on the subject and each of you has his own list or can get one from a former preceptor.

I shall conclude by remarking that the teaching of organic pharmaceutical chemistry is, in my opinion, an exciting exercise of the teaching art and a certain preventive of boredom.

ORGANIC CHEMISTRY AND ORGANIC MEDICINAL PRODUCTS AS A COMBINED COURSE

E. V. Lynn

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In the limited time allowed for this discussion, it is unnecessary to dwell upon the importance of organic chemistry for students of pharmacy. More than 60 per cent of the substances used in medicine are organic compounds of greater or less purity, and if we add the crude vegetable and animal materials, we find that nearly 90 per cent of all used drugs must be considered in the course. Each of you who teaches the subject is well aware that organic chemistry is of outstanding significance in the four-year curriculum. Indeed some have claimed that it is the most important single course in the whole program.

It must be conceded that the subject is broader than could possibly be covered in any arrangement under the present curriculum and that selection must be employed. There are approximately a half-million organic chemicals known, and an impressive share of these compounds is of more or less significance in medicine. Beilstein, which gives a resumé of the literature up to comparatively ancient times only, consists of 54 ponderous volumes. To attempt even a cursory discussion of all the facts noted in these volumes would be hopelessly futile. No matter who attempts to teach elements of the subject, it is necessary to make very careful selection, and thus no two textbooks or series of lectures on organic chemistry can possibly be alike. In order to present those matters that are peculiarly significant to the pharmacist, it is especially essential that one choose wisely or the course given will necessarily be a hodgepodge instead of an orderly treatment.

During the course of more than forty years' experience in attempting to initiate hundreds of students into the subject, your speaker has come to two definite conclusions about what can be done. The first of these conclusions is that one must employ the general point of view as contrasted with the specific, and the second one is that the important matters to be covered are nomenclature and properties. Let us examine these statements in more detail.

In the first place let us consider the general aspects as compared with the specific ones. It is customary to discuss a given class of compounds by noting the methods of preparation, chemical and physical properties, systematic naming, and perhaps other topics. As illustrations one selects any of the important medicinal compounds that belong in this class. The instructor could go still further along this line and give a complete list of all such compounds, together with numerous synonyms and trade names, and all of the mixtures and preparations that are marketed. No one could object to this presentation as a matter of record, but when the student is expected to assimilate and remember such an array of facts, the time consumed becomes inordinate. Any attempt to teach "chemicals" instead of "chemistry" in a relatively short space of time is almost certain to be a failure; one can only hope to see that the student knows the general principles and properties. A list of all compounds of the class may be given, as well as marketed mixtures and preparations, and one might even enumerate the specific peculiarities of each. Whether the student recognizes all of these at a future time is of much lesser importance; the crucial criterion is that he know thoroughly the properties of the class.

In the second place, may we consider the general matters that are of greatest worth to the pharmacist. A long-time survey of actual professional practice has convinced your speaker that only two items are of fundamental importance: namely, nomenclature and selected properties. The dispenser must be able to interpret the chemical names of any new or old compounds, whether official or otherwise, and be able to write structural formulas to represent them. Of course, just to set down such a formula is not an end in itself but rather a means for predicting the properties. Once having determined the formula, the operator should then be in a position to know the characteristics of the compound in question in so far as they might be of import for any subsequent handling. Only a brief consideration will be required to convince any of you that the number of such general properties is small and can be acquired by the student for any one class with comparatively little effort. Other possible general considerations than nomenclature and properties are of much less significance and can be relegated to the background. These considerations include methods of preparation and synthesis, industrial and other applications, etc. If you study the question thoroughly, it seems certain you will agree that the primary objectives in organic chemistry for pharmacy students should be instruction in general nomenclature and selective properties.

Unfortunately, the limitations of a four-year curriculum do not allow for completely adequate time. The rest of the basic sciences of biology, physics, physiology, bacteriology, pharmacology, pharmacognosy, and dispensing require considerable time from

the student, chiefly because of the necessity of learning a new technical language in each. Those who wrestled with the intricacies of the Syllabus are thoroughly convinced that the usual proportionation as noted in that volume is a maximum for the amount to be allowed for chemistry as a whole. If we allow sufficient time for general chemistry, qualitative and quantitative analysis, and biological chemistry, all of which must practically be included, and physical chemistry which some, as you know, think should be included, we have very little time for organic chemistry. Roughly speaking, this would be the equivalent of one full year, or about ten semester hours, unless, of course, the group of chemistry teachers as a whole could agree to a different percentage division. This maximum of ten hours could arbitrarily be reduced to eight or even six in order to add a course in organic medicinal products. But the point that should be particularly emphasized at this point is that, without sacrificing other portions of the curriculum, a limited amount of time only can be spent by the student in organic chemistry. Experts in any given field are naturally inclined to complain that they need more time for covering the subject, but a careful study of the whole four-year curriculum should convince even these experts in organic chemistry that there must be an inadequate maximum, which has been set at the present at about ten semester hours.

Our chief problem, therefore, is to utilize this allotted time to the best advantage. It is to be admitted that the faculties of most schools are still further restricted, in that the basic course in organic chemistry of eight to ten semester hours is completely out of their control. Under such circumstances, they must of necessity furnish a supplementary course to present those matters of nomenclature and properties of medicinal substances that have not been covered. It must be further admitted that the usual course in organic chemistry as given for students in a variety of fields does not provide for the chief needs of the pharmacist. In such cases it would seem evident that the student in pharmacy is undoubtedly penalized because the total amount of time allowable for organic chemistry is fixed, although not adequate, and any over-allotment must be at the expense of some other subject. It would appear logical that the instruction should be given within the fixed time, whatever that time might be, and it is the speaker's firm opinion that this instruction is most advantageously done by maintaining our primary objectives throughout, whether the teaching is in two consecutive courses or in a single one. In those instances where the primary objectives cannot be maintained in the first course because not under control of the faculty in pharmacy, the student is without doubt at a disadvantage.

Experience has taught that the most profitable method, where the primary objectives are maintained, is a single course of ten semester hours. This experience has involved several alternative arrangements of various kinds, including the pertinent one of a basic course followed by one giving the applications to medicinal substances. Actually, this method of giving two courses and adhering to the objectives in both sacrifices very little except the time required for a great deal of repetition, which with some students might even be an advantage. The chief drawback in any arrangement is usually that the instructor in the basic course does not realize, or prefers to ignore, the needs of the student in pharmacy. The ideal situation would be one in which the students in pharmacy are placed alone under an instructor who appreciates their needs and teaches accordingly. In that case, a second course in applications would seem unnecessary, although it could be given if the total amount of time were not exceeded. Use of a single course, however, under a sympathetic, qualified, and understanding instructor appears to be the most efficient method under any circumstances, again keeping in mind that the pharmaceutical objectives must be maintained continuously.

One good reason for completing the basic and applied organic chemistry in a single course is the necessity for sequence. Although the experiment at Brown University, as reported in the Journal of Chemical Education, is being watched with interest, most of us will agree that beginning work in organic chemistry cannot come before the second year of the student's college work. As we know, it is not given in any school of pharmacy throughout the United States before that time. This condition leaves a maximum of two years only for the subjects that cannot precede organic chemistry, such as physiology, bacteriology, pharmacology, analytical and biological chemistry, and the various phases of pharmacy and dispensing. Furthermore, some of these subjects are prerequisites for others; thus, a knowledge of physiology should precede any discussion of pharmacology. The speaker is well aware of the fact that some would place the sequence in different orders, mainly because of variations in proposed syllabi under any given caption, but he is convinced that the basic and applied organic chemistry is almost a necessity before about two years of essential subjects if we are to get even a reasonable efficiency.

Some would argue that this necessity might pertain to basic organic chemistry but does not to the applied. Having attended classes and lectures in all of the subjects that have been listed, both at his own school and elsewhere, your speaker cannot agree. The instructors who teach these subjects are continually making points with illustrations of organic medicinals, such as benadryl, novocaine, amphetamine, and a host of others. In fact, the use of such terms is almost automatic with them. They unconsciously assume that the student is intimately conversant with

such substances, when, as a matter of fact, he may never have heard of them. No, the applied organic chemistry is usually just as necessary for a good understanding of these subjects, which usually do, and logically should, follow any course in organic chemistry.

The most cogent argument, however, for a combined single course in organic chemistry is that giving such a course can be, and is being, accomplished efficiently. The essential basic work must concern itself with all general classes of compounds, but it would be impossible to discuss each of the known individuals, and no one would attempt to do so. Each teacher must choose certain substances for illustrating the class, and it is comparatively easy to confine the selections to medicinal products. Indeed, one can efficiently cover during the year all of the compounds that are used in medicine, without sacrificing any of the basic principles. It is admitted that all brand names and synonyms cannot be more than presented to the student, any more than they can be in the separated courses in most schools; there are just too many of them. One particular substance on the market today has as many as forty brand names, and the total of such names is tremendous. Let us be reminded, however, that our task is to teach chemistry and not a catalogue list of names. The point to be made here is that the subject of organic chemistry, including that of medicinal products, can be taught most efficiently and well in a single course in the second year of the student's college curriculum.

Let it be distinctly understood at this point that the single course is being advocated only under existing conditions, the most important of which is that the whole program be confined to four years of the student's college life. If we could have the student for a total of five years or longer, then one might easily be persuaded that repetition of the fundamental study with particular reference to medicinal products would present an advantage. Indeed, there is always considerable merit in repetition at any time. But logically we are faced with the necessity of confining our efforts to the equivalent of about ten semester hours, unless, of course, we purloin some amount of time from other subjects. In view of the existing circumstances, therefore, using a single course is the logical procedure.

Even under an arrangement whereby more than ten semester hours could be devoted to organic chemistry, the same reasoning applies. It is maintained that the most efficient treatment would be to keep our primary objectives throughout, whether in a single course or in two consecutive ones. Stated in other words, if more time were available, it would be better to divide the single course rather than repeat the basic study. In this connection it should be recalled to you that the basic study is being repeated every time a new class is considered, so that advocates of the great value of repetition as a means of driving home important points cannot have such an argument against maintaining the objectives throughout any two courses.

The proportionation of such a single course is naturally very pertinent. It is perhaps superfluous to assert that it should include a certain amount of individual work in the laboratory, although experienced instructors have been heard to maintain that the student in pharmacy does not need any such work in organic chemistry, in view of what we expect him to learn. The knowledge of properties, however, seems to be impressed much more firmly by the handling of certain representative substances, and the synthesis or preparation of a few compounds gives the student an idea of the problems that must be overcome by the manufacturer and of the impurities that might be encountered. Naturally, any illustrations that are used should as far as possible be selected from among the list of substances used in medicine and should be chosen particularly for the greatest amount of information on general properties of such compounds. In a ten-hour course the student ought to have at least three to four clock hours per week throughout the year in the laboratory. At the Massachusetts College of Pharmacy two three-hour periods are scheduled, but a variable amount of time is taken out of each period for discussion and about ten minutes for a written quiz. In the laboratory and in the class room there is one instructor for each group of forty students or fewer, rotated among the groups every week, and the lecturer is always one of these instructors. The lectures, three per week of fifty-five minutes each, are informal in that the students are at liberty to interrupt for the clearing up of doubtful points. Your speaker, incidentally, is retired from active participation in these lectures, but he is firmly convinced that discussions with the class accomplish more in the same length of time than do formal lectures and would eliminate the latter if possible.

In the time permitted today it is not possible to give you a complete picture of the course to be given. Even if such a picture could be transferred to you, it is questionable whether it would present a great advantage, because any one who has the responsibility of organizing a single course of this nature would wish to develop it along the lines of his own ideas. The right procedure would be to select the outline of any good textbook of organic chemistry and assign each of the medicinal agents to its respective place in the outline. A list of agents should include those substances that are in the Pharmacopeia, the Formulary, and New and Nonofficial Remedies, as well as the ones given in the Modern Drug Encyclopedia, the Red Book, and the Blue Book. From these different sources there will naturally be a great deal of duplication which must be eliminated.

The lecture material would be outlined much as it is in the textbook with special stress on nomenclature and physical and chemical properties. The student

should be made aware at the outset that these two phases are most important to him and that tests and examinations will be given to him from time to time to determine whether he has grasped the principles and can make use of them. In the lectures the instructor may wish to use as background much other information on history, methods of preparation and synthesis, industrial uses, toxicology, etc., but only under exceptional circumstances should the student be held responsible for this information. A complete mimeographed list of the medicinal agents in each class of organic compounds may be handed to the students when this class is discussed, and from such a list the lecturer may select one or two of the important substances for illustrating his points. If a list of this kind is passed out, each chemical compound should be accompanied by one or more names that are correct according to standard usage, and the student should be encouraged to write structural formulas to confirm for himself validity of these names.

Allow me to digress for a moment to note one feature of the instructor's problem - that of persuading the student to do the necessary amount of work. Experience over the years has shown that very few students can quickly and without a great amount of labor grasp the intricacies of systematic nomenclature. For most of them a relatively arduous and long term of practice at formulation is necessary. On the other hand, even the poorest survivor from the freshman year can master the subject of naming organic compounds if he is willing to devote sufficient time when it is necessary. A good illustration of this point was the experience with one particular individual who was much below the median in intellectual capacity. Early in the course he had considerable difficulty keeping up with the rapid advance of the class, although he was conscientiously eager to do so. The sympathetic instructor outlined what would be necessary and suggested that the student do his practicing study at a desk in the instructor's office. For the balance of the year the student did his practicing there for one hour a day, occasionally longer, and with no help from the instructor except in the classroom. At the end of the year he attained a rank in the class well above that of the average. From such experiences your speaker maintains that almost any student can reach the objectives of the course in organic chemistry if he is willing to put in the requisite amount of time, which is not inordinate. The problem for each instructor is to persuade members of the class that, while a good memory may help some, each one must devote considerable energy to the task every day. Furthermore, it must be emphasized that the information is accumulative, and one cannot afford to omit any one of the daily practice sessions.

One excellent method for accomplishing such persuasion is the custom of giving frequent written quizzes. The class should be informed that the subject matter for the questions may cover any points that have been made since the beginning of the year and that final grades in the course will depend a great deal on quiz averages. The instructor should correct the quiz papers carefully, not just grade them, and return each corrected paper to the student within a short time. With such written quizzes the capacity of the student is well indicated by the end of the year, and it should be possible to rate each student accordingly. As a matter of fact, any final examination under such circumstances becomes more or less a formality.

In order to utilize the foregoing principles to the best advantage, the faculty at our college has scheduled the course so that the student is in contact with an instructor in organic chemistry five days a week. The informal lectures of fifty-five minutes each are given on Monday, Wednesday, and Thursday, and the three-hour laboratory periods are on Tuesday and Friday. During each laboratory period sections of the class spend some time in a recitation room for conferences and quizzes. The practical work in the laboratory is selected with the object of giving the student most experience in learning general properties. He prepares a number of specific compounds and tests them for identity and purity, but most of the available time is spent in studying class reactions.

At this point, allow me to introduce a word of caution. The combined course should never be entrusted to an unqualified teacher just to get one with a background in pharmacy; that step would lead only to inferiority. Above all, the teacher should be capable of handling any course in basic chemistry and in addition he should have a complete background in the four-year curriculum in pharmacy. If such a teacher is not available, one should not attempt such a combined course.

In summary and conclusion, the speaker wishes to emphasize that it is our duty to urge better cooperation between the chemistry department and the faculty in pharmacy. He is thoroughly cognizant of the fact that many of you are the victims of circumstances without any control over what goes into the course in organic chemistry. To members of the chemistry department this course should be the same no matter what students are taking it, a view which is far from correct in our case. We should persistently lay the facts before the proper authorities and thus attempt to get a system that will be most advantageous for our students in pharmacy. Above all, they should be in a class by themselves; if the number of them is too small for the funds available, certainly the recitation section should be composed only of pharmacy students under a sympathetic instructor. The latter, even though he may be willing, is more or less helpless without our help. We should advise him continually and furnish him with a classified list of medicinals, complete with synonyms and brand

names. Under such new circumstances, we would find that the students would come to us with considerably better preparation and, even if we decided to give them a further course in medicinal products, they would be just so much better indoctrinated to take it. Again let me repeat that the ideal situation lies in a class for the students in pharmacy alone and under a teacher who knows what they need. Our greatest efforts should be directed toward securing active co-operation from school authorities and the department of chemistry in order to establish a condition more favorable to our students.

TEACHING THE CHEMISTRY OF SYNTHETIC ORGANIC MEDICINAL PRODUCTS

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Chancellor Hourse of our University says that after the close of hostilities in 1865 Chapel Hill was occupied, in part, by Michigan cavalry, and the horses were stabled in the reading stalls of the library. As a result of the close association between horses and students the men of North Carolina have become noted for their horse sense, and the Michigan horses have acquired a reputation for learning. You will understand, therefore, that I gave a good deal of thought to the invitation to participate in this program at Ann Arbor, in the state where even the horses have such a remarkable intellectual rating.

I have been assigned the subject, "Teaching the Chemistry of Synthetic Organic Medicinal Products." Allow me to say at the very outset that I am not so presumptuous as to believe that I am an authority on the teaching of anything. If I were to select a motto for this presentation it would be the well-known quotation from Shakespeare's Portia, namely,

> "I can easier teach twenty men what were good to be done than to be one of the twenty to follow mine own teaching."

Nevertheless, I do not react neutral to people who seem to have all the answer to this business of teaching. In my opinion we will do well to recast much of our thinking.

Perhaps I can illustrate what I mean by reminding you of the case of Ignaz Semmelweiss, the Hungarian obstetrician (1818-1865), who discovered how child-bed fever was transmitted and how it might be controlled. He showed that the physicians themselves were the agency by which the infection was carried from one bed to another; and when he and his assistants washed their hands with chlorinated lime the progress of the disease from one patient to another was halted. But Semmelweiss's method was disapproved. A reading of his biographies appalls one at the philosophy of medicine of the time. The reputable physician was much concerned about what was considered good practice; if the patient died it was unfortunate to be sure, but that in no way detracted from the fact that the physician had comported himself properly; of course, if the patient recovered, it was all to the good but still incidental to the practice of medicine. Semmelweiss had shown how to keep young mothers alive, but he resorted to unapproved measures, for which he was censured. No wonder he died a brokenhearted and defeated young man.

It is still true, I presume, that our colleges and universities exist for the purpose of educating and training our more intelligent boys and girls and for productive scholarship. It is altogether proper that we of the faculty be concerned that this be done effectively and proficiently. But in this endeavor let us not be like the colleagues of Semmelweiss, who forgot the raison d'être of their profession. Lest you think there is no such risk, allow me to cite several cases which are known to me personally.

At the close of World War I, unsettled in my plans, I accepted an appointment to fill out a teaching vacancy in the high school at Forest Grove, Oregon, located in a delightful town and with an enrollment of better than average students. I enjoyed the experience and, I am happy to say, I was re-elected at an increase in salary. When I accepted the initial appointment I had the B. A. degree, but I had taken no "education" courses; however, because of the shortage of teachers at that time, the superintendent was able to obtain from the state board of education a temporary permit for me. When I was re-elected he had also arranged for an extension of that permit on condition that I earn during the next two summers the legally required sixteen semester credits in "education." My teaching responsibilities, however, included two subjects one of which I had never taken; the other I had taken only in high school. Therefore I argued that if I were going to continue with those subjects I owed it to the students first to become familiar with that subject matter. My superintendent agreed, but the state officials ruled otherwise.

A former colleague at Maryland, whose specialty is mathematics, also taught an evening extension class in first year college mathematics, in which many Baltimore teachers enrolled. Not many years ago there appeared among the applicants for admission to this course a recent graduate from a state teacher's college, who had satisfied her teacher training requirements in mathematics, and theoretically, was qualified to teach the subject in high school. She was denied admission to this freshman algebra class, however, because of insufficient prerequisites and was advised to make up the deficiency in evening high school. One wonders why, with her legal qualifications to teach mathematics, she was not her own first efficient pupil!

Other examples might be cited, but these are

enough to show the direction of my thinking. But lest I appear as a lone actor in this respect, allow me to quote from Joel H. Hildebrand, the well-known professor from the University of California. I shall, in fact, take the liberty of quoting extensively from his two recent papers, the one given before the Division of Chemical Education at last September's meeting of the American Chemical Society and appearing in the Journal of Chemical Education 29, 112 (1952); and the other appearing in the May 19 issue of Chemical and Engineering News, p. 2072. Dr. Hildebrand says: "There are current proposals to set up special curricula for training college teachers. I think we should be very cautious about moving in that direction. It is all too easy to assume that when an existing agency is not functioning perfectly the thing to do is to set up a new one instead of to overcome the faults of the existing one, forgetting that the substitute is quite likely to develop weaknesses of its own. Whenever training for teachers is removed from exciting contact with a major field of intellectual activity, it becomes absorbed in mere methodology and loses creative drive. A teacher thus trained is like an artist who has learned technique but has no creative imagination, or a piano player who performs dexterously with his fingers but not with his soul, who can astonish by his acrobatics but who cannot interpret the works of great masters."

The student-subject-professor relationship is not simple. If you will indulge me I shall for the present dwell not so much on how the professor transmits the subject matter to the student as on what the professor has to transmit. It behooves us as professors perpetually to examine our competence. I am sure we will all agree that the teacher cannot transmit what he does not have, even though he be endowed with the best transmission technique or equipment in the world.

Let me say again that I am here expressing my own opinions, and none is obligated to agree. Not long ago, for example, in discussing the teaching of fundamental analytical chemistry to pharmacy students with a young professor I ventured to state that an expert analyst could do a better job than either he or I. His reply was, "Speak for yourself." Thus I presume to speak for no one else now.

The first requirement for one who would teach the chemistry of synthetic medicinal products is that he be familiar with his subject, not to say expert in it. It is not up to me to rate the various professors, for while I may do so in my own mind I would not insist that I am correct, nor would I be so indiscreet as to publish my estimates. Yet there are various criteria by which it is possible to measure ourselves. I shall suggest several of these.

To begin with there is the academic degree, a great thing, indeed. The diploma is beautiful when framed and, hung on the wall, is silent but eloquent testimony to academic achievement. When necessary, it may even serve as squelching evidence to refute those who might consider us ignorant.

Then, there is the academic appointment. The approval of the college administration and of the trustees has about it something so impressive that it would ipse facto bear witness to the competence of the appointee. Or does it? How do others feel about us?

Several years ago I had occasion to discuss with a friend, who holds a responsible position in pharmaceutical industry, an applicant for a job. I knew this applicant could not be recommended without reservation, but I insisted that if he were properly placed he would prove useful and valuable. My friend replied in effect, "He'll never do in industry; why don't you get him a teaching job?" I cite that not as something which we should strive to live down to but as one successful man's estimate of professors.

And then, have you heard of the "sterile" Ph. D.? And one is tempted to ask "sterile" professor? That is, of people for whom all change and progress seems to have stopped when they satisfied their requirements for the degree, or received the appointment? You have no doubt heard, as have I, of the fellow who went on for the advanced degree only because without it there would be no promotion in academic ranks. Rather, the degree opens up opportunities and the appointment to a college faculty should be considered a challenge to achievement, an encouragement to scholarly production and not a reward for past accomplishments. These are, in effect, a prepayment for something that is expected of us in the future.

After he has his degree and his appointment the teacher owes it to himself, to his students, and to his university, not to say his profession, to keep up with developments and to contribute to them as much as possible. For the man working in the field of medicinal chemistry this is not always easy. I am not going into a long discourse on that subject, for all of us are fully aware of the rapidity with which new therapeutic agents make their appearance and those that a few years ago were headliners become obsolete. But allow me to indicate several other reference points in terms of which we may continue with our self-evaluation.

What do we have in our personal libraries? I know how expensive it is to buy books and to subscribe to journals. Yet, somehow, the books and periodicals which we have are an indication of our interest, and the dates of publication of these materials are an index of the present vitality of those interests.

Another reference point I would propose is our attendance at conventions of the learned societies and at scientific meetings, where we have the best chance of learning the latest about the newest, or the newest about the latest. Remember we are still talking about organic medicinal products. Of course it is a physical impossibility to attend them all and

it would be financially unendurable. I certainly should not want to prescribe those we should attend. Yet, if you were to permit me to make a diagnosis, it would be based on such symptoms as the following.

Last September the American Chemical Society, on the occasion of its diamond jubilee, combined with the International Union of Pure and Applied Chemistry for special programs in New York City. There were excellent programs on medicinal chemistry; distinguished visitors came from abroad to take part in these programs and to contribute to the celebration. This was an unusual opportunity not only to meet with our own countrymen but to see, meet and talk with distinguished men who will not soon come again, especially in such large numbers. At these meetings, so far as I was able to ascertain, only six or at most seven schools of pharmacy were represented.

The Division of Medicinal Chemistry of the American Chemical Society has organized national symposia, the third of which recently concluded its sessions at the University of Virginia. Among those attending and taking part in these gatherings are many of the leaders of medicinal chemistry from industry, from the government laboratories, and from educational institutions, and usually there are present also several distinguished foreign visitors. Disappointed in the past with the attendance from pharmacy schools, I made a special effort to note the number represented this year. I counted ten institutions. I am still trying in my own mind to learn who should be more interested in such programs than those who are teaching medicinal chemistry to pharmacy students.

I'll agree that attendance at such meetings does not automatically make us better teachers. I will also agree that each school not represented, or each professor who was absent, may have a perfect and adequate reason. But, considered statistically, do not such things indicate a sad deficiency among our schools and faculties?

If I am correct in this diagnosis, then the deficiency cannot be compensated for by substituting teaching outlines, syllabi, trick teaching methods, and the like, although they may go a long way in masking what ails us.

What about the teaching of synthetic medicinal products? I am not convinced that at the undergraduate level we should emphasize the distinction between synthetic and other drugs to the extent that they should be given as separate topics or courses. The origins of the medicinal agents may be different, it is true, but their chemistry is the same. If the individual teacher feels that he can make a better presentation by making such a division, I should not quarrel with him.

At this point I ask the privilege of quoting again from Professor Hildebrand, who says: "Good teaching is a personal performance. Each teacher must do it his own way. It cannot be more achieved by recipe than can production of a work of art. Nor can it be done by slavish imitation of another."

As one of the chief qualifications for the man who would teach the chemistry of synthetic medicinal agents, nothing is more important than that he have experience making some. Experience conveys something that cannot be gleaned from textbooks or laboratory manuals. You are familiar with the term "Sprachgefühl" as applied to the linguist; so also there is a "Laboratoriumsgefühl."

Let me cite the experience of a friend, who is professor of organic chemistry in one of our New England colleges. He was adopting a new laboratory manual, authored by a big-name American chemist, and during the summer he performed according to the directions of the manual every experiment he would assign to his students. In the simple experiment of nitrating benzene he always found low yields of nitrobenzene and high amounts of dinitrobenzene. His interest aroused, he resorted to the library where he found that the directions for the experiment were substantially those of the latest edition of the well-known manual by Gatterman, and that the Gatterman manual had not been appreciably changed for nitrobenzene since the earliest editions; checking on the nitric acid first available to Gatterman, my friend found that it was not so concentrated as that now available; he went back to the laboratory, diluted the nitric acid to the concentration Gatterman first used and, presto, the indicated yield was obtained.

Allow me to refer again to my assigned topic, "Teaching the Chemistry of Synthetic Organic Medicinal Products." I have already indicated that I see no good reason for making a distinction at the undergraduate level between medicinal products obtained synthetically and those obtained otherwise. For example, to use a simple illustration, if one employs either the chemical or the pharmacological classification of medicinal agents, should he discuss epinephrine in a course on "natural" products and cobefrine in the course on synthetic products? I am still willing to leave that to the judgment of the individual professor. But there is another matter to which I would direct your attention, lest the title of the topic as worded give the wrong impression. The chemistry of medicinal products, whether of synthetic or other origin, is like the chemistry of products not used in medicine. Too frequently in talking with pharmacists one is likely to get the impression that in the pharmaceutical domain chemistry may become a bit unorthodox, and we who aspire to be educators are reminded that we are not teaching chemistry but pharmaceutical chemistry. Have you ever had the feeling from talking with some pharmaceutical educators that they would be happier if they could get away from chemistry altogether? Let us not forget that the origins of chemistry are deeply rooted in pharmacy. Rather, we need the viewpoint of Professor Urdang, the eminent pharmaceutical historian, who tells us that

it was precisely because they were pharmacists that so many contributed to the early growth and development of chemistry.

Hence, I opine, that anyone who would teach synthetic organic medicinal products should be a top-notch organic chemist. I do not agree with the advice I recently overheard a dean receive from a professor of pharmaceutical chemistry in one of our better known universities. The dean was debating whether he should appoint as pharmaceutical chemistry teacher a man with a doctorate in organic chemistry but a definite interest in medicinal products or a man with the B. S. Degree in pharmacy. The advice was to take the B. S. man, since by training he had the pharmaceutical background. I shall not elaborate on that, but the dean, I am happy to say, did not accept the counsel and in my opinion that school as well as the entire pharmaceutical profession is the better for it, for the young professor is doing excellent work.

Professor Hildebrand speaks of L. G. Sillén of Stockholm, who is interested in the half life of the various materials which make up the intellectual diet served by professors. The half life of such an item is defined as the time it takes for half of the students in the class to forget it. This is an intriguing concept and somewhat aside from the general topic of my discussion. But it does prompt speculation along this line. The half life of radioactive elements is invariable, but to what extent may a professor influence the "half life" of the materials he deals with in his lectures?

As for the teacher, allow me to quote further from Hildebrand: " . . . The character of the teacher, if it seems admirable to the student, may influence him strongly, but what a teacher <u>is</u> far outweighs what he <u>says</u>. We need not courses <u>on</u> character but teachers <u>with</u> character -- teachers who are so honest that they first of all try to do a competent job with the subject. There is no substitute for professional competence. Of course, good teaching does not stop there, it requires not only thorough knowledge of the subject but also sympathetic understanding of students. . . .

"In my long observation of student motives, attitudes and reactions, I have come to the conclusion that where a sense of hostility exists it is more often between student and teacher than between student and subject, and where the latter exists it arises all too often from a spread of distaste from instructor to subject . . . .

"I must not neglect to mention another, even simpler method of appraising one's teaching, which is to look into the faces of the class for signs that their minds are in operation. A teacher has ample opportunity, from the responsiveness of his class, from informal quizzing and from friendly conversation with individual students, to appraise the effectiveness of his teaching."

If I have been unconventional during this discussion of the student-subject-professor triangle in giving emphasis to the professorial element rather than to the usual question of what the professor presents or how he does it, I am sure you will still agree that this is a phase that requires serious thought and must never be forgotten. From my own student days and from my own feeling of responsibility as a teacher, I have a strong conviction that the individuality and enthusiasm of the teacher cannot and must not be standardized or normalized. The personal relationship between student and professor, though regrettably attenuated in these days of large enrollments, is still a vital force in education.

James A. Garfield, discussing the value of a true teacher before the Williams College Alumni, New York; December 28, 1871, said,

> "Give me a log hut, with only a simple bench, Mark Hopkins[1] on one end and I on the other, and you may have all the buildings, apparatus and libraries without him."

With teachers who are interested in their responsibilities and opportunities and enthusiastic about their specialty there won't be much occasion to tell them how to teach the chemistry of synthetic organic medicinal products or whether to teach it as a separate subject.

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[1]Mark Hopkins, president of Williams College, 1836-1872.

EXPERIENCES IN TEACHING ORGANIC PHARMACEUTICAL PRODUCTS

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The course "Organic Pharmaceutical Products" is now offered to the junior students at the University of Minnesota, whereas previously it was a senior subject. Several reasons prompted the selection of the junior year in preference to the senior year. First, this course deals with a goodly amount of organic chemistry and this prerequisite is given in the sophomore year. Even though this prerequisite immediately precedes the course under discussion, nevertheless the student of average ability and less has difficulty with this phase of the subject. This is no doubt due to the fact that the average student has a poor aptitude for organic chemistry. In addition, these students have considerably less ability to retain much of their fundamental organic chemistry. Second, dispensing and pharmacology are given in the senior year, and it is believed that much information given in Organic Pharmaceutical Products will be of distinct value in those courses mentioned. In fact, Organic Pharmaceutical Products is one of the prerequisites to dispensing.

Many other courses such as inorganic chemistry, physics, physical chemistry, bio-chemistry, physiology, biology, bacteriology, zoology, etc., should be classed as prerequisites to Organic Pharmaceutical Chemistry. The first two years of the pharmacy students' training, however, does not include all of these subjects. Furthermore, some of these very desirable courses are not given at all because of the inability to crowd them into the present four-year program. In some cases, therefore, the students do not have the proper background to gain the maximum benefit from the course as it is now presented.

A second important experience I have to report on the teaching of Organic Pharmaceutical Products is a consideration of the course content. All official and nonofficial useful organic compounds from the hydrocarbons through vitamins are given some consideration, some more than others. Ten quarter-credit hours are assigned to this course. The following points are considered: (1) official titles and synonyms; (2) nonofficial synonyms; (3) historical development; (4) source and preparation; (5) significant physical and chemical properties; (6) mode of action; (7) structure with relation to activity; (8) uses only (no pharmacological discussions); and (9) dose. An attempt is being made to cover these points to the best of my ability. Should all these points be covered in one course? There is no question about the desirability if not the requiring of these points in the pharmacy curriculum with additional pharmacology of these drugs.

Because such a large number of organic compounds are available for medicinal use and because the coverage for these compounds is quite extensive, I find that ten quarter-credit hours is not enough time. Perhaps I have spent too much time on this or that group of compounds or perhaps I have gone overboard along certain lines. I try to watch my time as closely as possible so that I do not intentionally commit these errors.

I am not going to comment on points 1, 2, 8, and 9 because I feel that they are self-explanatory and I have not had any unusual experiences with these points. I should now like to comment on my experiences with the remaining points and I will discuss them in numerical order.

3) A discussion of the historical development of any drug usually is one of the most fascinating phases of the study of a drug. It is not only very interesting but it is also very instructive to the student. Unfortunately, the amount of time that can be devoted to this very important point is too limited. Perhaps outside reading to supplement the lectures would be the answer. The only difficulty with outside reading on this point is the lack of convenient availability of this subject matter in an organized and concise form.

4) The presentation of the source or preparation of an organic medicinal compound has presented me with some problems. I find that some of the simpler syntheses do not offer too much of a problem and probably are of a distinct value to orient students to the compound or series of compounds in question. Beyond this value I am beginning to believe that for the average undergraduate student this should suffice, because even in the synthesis of some of the simpler compounds, a number of synthetic approaches are possible. The problem, therefore, then arises, Where is one going to draw the line in the presentation of the syntheses of a given compound? Insofar as the syntheses of some of the more complex drugs such as some of the vitamins, cortisone, etc., are concerned, I can see no marked advantage in presenting these syntheses in formal lectures to undergraduate students. I should like to add that I believe a number of laboratory experiments of carefully selected syntheses would be of a distinct value as an adjunct to the lecture material.

5) I believe many significant physical and chemical properties would become more apparent to the student if a number of carefully selected experiments were chosen as laboratory exercises to supplement the lectures. These experiments could very well include descriptions, solubilities, stabilities, chemical reactions that may or may not be desirable when the drug in question is to be compounded in a certain fashion, and so forth. Where ever it is possible, the student is introduced to the role that the physical and chemical properties play in regard to absorption, cumulation (drug depots), excretion, etc. These points are further elaborated upon under point 6. These approaches are more on the order of an orientation nature and are certainly adapted rather nicely to this undergraduate course.

6) The mode of action, when known, is presented so that one can pinpoint the original focal mechanism which initiates a series of changes that are ultimately manifested by the clinical symptoms detected by the clinician. Such a discussion is necessary to an understanding of why the drugs we have are useful.

7) A discussion of structure with relation to activity logically follows the mode of action and clarifies in the student's mind the reason for the use of a certain series of drugs. This discussion must be quite limited at the undergraduate level and should be made just as brief as possible and still give the student a reasonably clear picture. I have found that students are generally not prepared sufficiently to gain the maximum benefit from the discussions given under points 6 and 7.

I do not deal with detoxication of drugs as a complete or separate subject. I find it quite convenient to discuss this phase only if it has to deal with the development of a drug or when the metabolic product is more or less active than the parent drug. This phase might best be discussed under mode of action or under historical development as the case may be or where I feel that the student will be able to absorb it to his greatest advantage. A more complete discussion on detoxication of drugs, I think, should more properly be given by the pharmacologist or the toxicologist.

The synergistic action of drugs is not emphasized enough in most courses. I feel it is an extremely important phase of drug therapy and, unfortunately, this field has not been exploited as much as it could be. Little, to my knowledge, has been reported in the literature in the line of good reviews or portions of textbooks that could be used as a source of information for teaching purposes. I realize that, however marked my interests are in connection with the synergistic action of drugs, a detailed discussion along these lines should more properly be discussed in detail by the pharmacologist. The introduction to this phase of organic pharmaceutical products can be integrated with mode of drug activity.

I do not believe there is the time or place in the course in Organic Pharmaceutical Products to include in my lectures the following details: (1) many "commercial" trade names, (2) the preparations, official and otherwise, that may contain the organic pharmaceutical product currently being discussed in lecture, and (3) many other organic compounds that are available but have been proven to be of little value or do not show promise of being useful drugs.

I have recommended that Organic Pharmaceutical Products or its equivalent be a prerequisite to graduate instruction in this field. This circumvents the necessity of repeating much fundamental and useful information given the graduate courses. This undergraduate course furnishes a good introduction to the field of organic drugs and, therefore, I perhaps may, in some cases, become a little over-enthusiastic. Undergraduate students may at times wonder what application can be made of this information to the practice of retail pharmacy.

Some graduate students in other fields elect a minor in pharmaceutical chemistry. I require them to take as part of this minor ten credits in organic pharmaceutical products. I know many of them have had little in the line of the desired prerequisites; however, they are permitted to take this course for what they can get out of it. It has been assigned a graduate number and is accepted for credit in the Graduate School.

The experiences I have just presented have been given essentially in an abstract form primarily in an attempt to keep within the planned time schedule. Those of you who are teaching a course comparable to Organic Pharmaceutical Products must have encountered the same or similar experiences. I shall conclude by saying that I hope the discussion period will help to clarify, if necessary, any doubtful or ambiguous statements I have made.

TEACHING THE CHEMISTRY OF ORGANIC MEDICINAL PRODUCTS USING A PHARMACOLOGICAL CLASSIFICATION

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A few years ago an instructor, whose first love was pharmacology, was assigned the task of teaching the chemistry of organic medicinal agents. Although as a graduate student he had taken a minor in chemistry, he presented this course from a purely pharmacological standpoint. Unfortunately, at that time the prerequisite was only five hours of basic organic chemistry, with about two weeks usually being devoted to aromatics and heterocyclics. It is obvious that under such circumstances the course in organic medicinal agents should have been organized with a strict chemical classification in order to compensate for the serious deficiency in organic chemistry. It was most regrettable and inexcusable that the opposite direction was taken and that a heavy superstructure of pharmacology was built upon a flimsy chemical foundation.

Despite the fact that our interests lie in the organic chemistry of pharmaceuticals, we can see that there might likewise be a danger in the overemphasis of chemistry to the detriment of pharmacology. It is possible that a skyscraper foundation is being laid for a one-story pharmacy. In other words, if the pharmacy student has passed eight or ten hours of basic organic chemistry, as administered by a department of chemistry, he should be able to distinguish for several years thereafter between an aldehyde and an amine. When such a background has been offered to a student, the instructor should then be able to employ a pharmacological classification in teaching the chemistry of organic medicinal products.

If the instructor of this subject will hold in check his exuberance over various pharmacological phenomena, while using a pharmacological classification, he may even do a better job of teaching the chemistry involved. For example, under the heading of various pharmacological classes, he will have the opportunity several times during the semester to remind the student of the nature of amines. A chemical classification, of course, lacks this particular repetitive feature. On the other hand, a strict chemical classification, which scatters information on substances of the same therapeutic class throughout the breadth of the course, may actually disturb and confuse a student when he needs help with pharmacological terms which are new to him. For example, if an instructor mentions the direct-acting parasympathomimetics, a new term at the time for a student, he should follow the discussion by a study of the agents which act indirectly. Otherwise, such terms may be almost meaningless to the average student when encountered several lectures apart. While it seems that little would be lost in chemical clarity by combining the discussions of such agents, the student would be aided a great deal in establishing a strong bridge between organic chemistry and pharmacology, which is assumed to be one of the main objectives of a course in medicinal chemistry.

Only during the past year have we finally become fully convinced that the use of a pharmacological classification in undergraduate organic medicinals would be wise. This decision came when it was discovered that each year we have been gradually shifting the organization of the course to that end. Actually, we have been using both classifications. For example, prior to the discussion of vitamin A, an outline of all the vitamins was presented and attention was called to the alphabetical naming of the vitamins based upon the similarities and dissimilarities in mechanisms of action. This outline was mentioned each time a different vitamin was encountered in following the regular chemical classification.

In our course, BHC and inositol are both mentioned twice, once under halogenated hydrocarbons and again under cyclic alcohols, thereby affording incidentally two opportunities to illustrate the principle of metabolite antagonism.

When the chemical classification is used, the synthetic or artificial estrogens are studied before the natural estrogens. We have felt that it is virtually a necessity to discuss briefly at least such products as estradiol and estrone before the artificial hormones are mentioned.

Undoubtedly, other instructors have followed the same scheme, and much can be said in favor of this type of repetition, although it is time consuming. However, a complete change to the pharmacological system of classification would conserve time for other valuable material, and we believe, result in less confusion for the student.

In studying morphine alkaloids and their substitutes, with an opportunity to point out the relationship between structure and activity, we have caused students to look throughout chemically classified texts for the necessary information. Actually, these substances do possess strong chemical similarities,

although the usual chemical classifications disperse them under various headings. While a pharmacological classification appears to be better for demonstrating structure-activity relationships, it also performs a service in showing a striking lack of such correlations in many cases.

A pharmacological classification would allow salicylic acid to be placed alongside acetylsalicylic acid, where it reasonably belongs. Only when the students have had no separate basic course in organic chemistry, or only an inadequate course, do separated discussions of these substances seem to be warranted.

The significant grouping in radiopaque compounds is the iodo, yet these compounds are usually spread throughout texts because the classification is based upon other functional groupings. Thus, such compounds are needlessly separated widely under the headings: phthaleins, iodinated fatty acids, iodinated fatty esters, hydroxy aromatic acids, and nitrogen heterocycles.

It has been observed that many pharmacists are unaware of the value of certain quaternary ammonium compounds as antiseptics. One might speculate that this results partly from the fact that these compounds are organizationally separated from the phenols and mercurials which have been for years the classic antiseptics.

It might be said parenthetically that the schools and colleges of pharmacy which offer pharmacology as a prerequisite to the chemistry of organic medicinal agents are presumed to demand a strong general course in organic chemistry as a prerequisite to pharmacology. Further, the assumption is then made that a pharmacological classification should logically be retained for the course in medicinal chemistry.

Before adopting another system of classification, an instructor may wish to recall an established precedent which is analogous to the problem under discussion. For many years elementary organic chemistry has served successfully as a prerequisite for the basic course in biological chemistry, in which subject the classification of organic chemistry is not retained. Actually, complex organic structures are employed in early parts of the usual course in biochemistry. Further, we recall that scores of chemists with ten hours of organic chemistry as a background have successfully completed graduate courses in organic medicinal chemistry which were organized by means of a pharmacological classification.

Traditionally, the pharmacist has been identified also as a chemist. While we who are attending this seminar are readily able to cite the tremendous contributions of chemistry to the pharmaceutical profession, we must admit that the modern practicing pharmacist in this country prepares few of the medicines which he dispenses. Also, more and more we see the advantage of a balanced basic training program which enables the student to go into one of the several divisions of pharmacy. The comparatively recent introduction of pharmacology into the curriculum has been a progressive step in this direction. While the practicing pharmacist is virtually never required to isolate a hormone from a natural source or to synthesize a barbiturate, he is expected to be acquainted with the toxicity and pharmacological action of a drug. So, one wonders if the retention of a chemical classification in the teaching of organic medicinals is not a heritage from the days when a pharmacist was known as a pharmaceutical chemist who was responsible for the complete preparation of his products. By adopting the proposed classification we should be acknowledging the need of an early exposure of the student to pharmacological terminology. At the same time we should be able to continue the teaching of pharmaceutical organic chemistry.

In summarizing, it appears that with a truly basic course in organic chemistry as a prerequisite it would be advantageous to offer a course in the chemistry of organic medicinal agents which employs a pharmacological basis of classification rather than a chemical basis. With a brief or inadequate prerequisite course in organic chemistry, the instructor would be wise to retain a chemical classification.

DISCUSSION OF "TEACHING THE CHEMISTRY OF ORGANIC MEDICINAL PRODUCTS USING A PHARMACOLOGICAL CLASSIFICATION" BY J. H. BURCKHALTER

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I well realize the diversity of opinion with regard to the merit of using a pharmacological classification in the teaching of medicinal chemistry. I must state at the outset, however, that I do favor this procedure and during the discussion of Dr. Burckhalter's paper, I will indicate to you the basis for that belief.

The present day trend in pharmacy education is in the direction of more adequate biological training. This is a natural consequence of the fact that the practicing pharmacist, regardless of his original intentions, is a practicing pharmacologist. He is directly involved in providing a drug to the patient for the treatment of a specific condition, usually at the physician's request. To be sure, he does not directly administer the drug, as may be the case with the pharmacologist, but nevertheless he must know something about the therapeutic and toxic actions of the material he is dispensing. For the rest of his life he will be using pharmacological terms, and will be called on frequently for related advice and information. Accordingly, if the practicing pharmacist needs to know the pharmacological action of a chemical, why not provide him with a pharmacological viewpoint as soon as possible by teaching medicinal chemistry on that basis? As Dr. Burckhalter pointed out, this does not necessarily preclude the dissemination of a sound knowledge of the chemistry involved. On the contrary, because of repetition, the chemistry of similar structures will become more firmly entrenched in the mind of the pharmacist in training.

I agree most wholeheartedly with Dr. Burckhalter's comment on the need for a thorough basic organic chemistry course for pharmacy students prior to their enrolling in medicinal chemistry. However, I would emphasize that under no circumstances is medicinal chemistry, taught with either a chemical or a pharmacological classification, a substitute for a basic course in organic. The providing of a thorough background in organic chemistry is a problem to be faced squarely by any pharmacy school administration and solved accordingly.

Another point which is more closely related to my particular field, that of pharmacology, is the realization that at best pharmacy students do not have a background necessary to an adequate understanding of the principles of pharmacology. Even the presentation of the pharmacological classification of drugs, along with the necessary terminology, is of great value to teaching in pharmacology. Since the student has some conception of the types and names of the drugs having a common action, he can expend more of his effort in assimilating the fundamentals of pharmacology.

There is another definite advantage in using a pharmacological classification in medicinal chemistry, one to which Dr. Burckhalter made reference in his presentation, and that is for purposes of consideration of structure activity relationships. It is obvious that there is some common denominator in a series of chemicals having the same biological action even though they may have no apparent structural similarity. I am convinced that if we could extend our chemical and biological knowledge, the answers would be ours for the asking. To cite an example, chloral hydrate, which is familiar to all of you as a central nervous system depressant and is arbitrarily classified as a hypnotic, has been listed for many years as an exception to the lipoid theory of narcosis. Recent investigations have demonstrated conclusively that chloral hydrate undergoes a biotransformation into trichlorethanol in the mammalian organism, and that the trichlorethanol is the agent actually responsible for the depressant action. Trichlorethanol fits into the theory very nicely. I could cite numerous other examples but the chloral hydrate story serves to illustrate the point. If we are to roll back the frontiers of knowledge of structure activity relationships, we must enlist the interest and ingenuity of an ever-increasing number of well-trained investigators and what better way is there than to attract students of high caliber? I feel that a course in medicinal chemistry could perform that very service and I believe that such a course, using a pharmacological classification, could be made more dynamic and more likely to fire the spark of investigative interest in the present students who will become the investigators of tomorrow.

Before closing, a few comments on pharmacological classification would be apropos. I must confess that the present system of classification is not entirely satisfactory, and undoubtedly you have frequently encountered objections to it. Much of it is arbitrary and not particularly scientific. Unfortunately, pharmacology is now in the position of organic chemistry in the latter part of the nineteenth century. However, attention is being focused on some of the

problems of the organization of pharmacological knowledge, and I can foresee the time when drugs will be classed on the basis of their action with structural or enzymatic components of the individual cells. For example, we may classify a chemical as to whether it is a succinoxidase inhibitor, copper chelator, etc. In one instance such a grouping is now being used quite generally -- that of cholinesterase inhibitors. So if one considers the use of a pharmacological classification in medicinal chemistry, one must be ready and willing to change.

I agree with Dr. Burckhalter that the advantages of the use of pharmacological classification in the teaching of medicinal chemistry outweigh the disadvantages and serve to make it a more interesting and dynamic course, and that the use of this classification should therefore be recommended.

TEACHING THE CHEMISTRY OF ORGANIC MEDICINAL PRODUCTS USING A CHEMICAL CLASSIFICATION

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In a discussion of the methods of instruction in a particular course of the pharmacy school curriculum, certain generalities should be considered that provide a basis for judgment of the merits of any given method. The pedagogical approach in the presentation of a course at the college level in which the chemistry of organic medicinal products is usually presented, should be characterized by the attributes of education as opposed to those of inculcation. For the achievement of this objective, the presentation of the chemistry of organic medicinal products or any other course will probably not conform well with the pattern followed in all too many courses in which scholastic accomplishment seems to be commensurate with the unimaginative encyclopedic component of the student's knowledge. The appraisal of students scholastically often appears to be independent of their relative creative theoretical capacities. Knowledge of facts is a feat of memory and is important primarily not because it provides known solutions to old and recurring problems but rather because it supplements the reasoning and intuitional processes of an individual's thinking as he seeks solutions to new and uncommon problems. A student who has been inculcated rather than educated graduates with the knowledge of what frequently is a random and arbitrary selection of facts and with the forewarning not to depend on his memory. A satisfactory course in the chemistry of organic medicinal products should be geared for the instruction not only of those capable of learning the "who and what and when" but of those who can learn also the "how and where and why."

The challenge to the instructor and his teaching responsibilities are quite different when he refrains from presenting a mass of known solutions to recurring problems with the admonition that memorizing a certain minimum of such material is consistent with a passing grade. The dogmatic transcription of tabulated data to the blackboard, a common form of inculcation, is far more terrifying than inspiring to the student. The instructor, not the student, should concentrate his attention on the compendia of monographs, the handbooks of tabulated data and the manuals of scientific knowledge summarized and simplified, which are so often employed as textbooks in courses in a college of pharmacy.

When a student has endured two to three years of inculcation in many of his courses, his reaction to education is interesting to watch. The indolent student resents the necessity of taking lecture notes carefully, reviewing courses of basic importance in connection with current studies, and spending time in the library for collateral reading assigned, suggested, or otherwise. His scholastic achievement, objectively and equitably measured, is generally inversely proportional to his resentment. He frequently will object on the grounds that the ratio of his preparation time to the credit hours in the course is unfavorably high in comparison with that in other courses. He will sometimes contend that no relationship exists between the material assigned and the questions on the examination. An association of ideas through the process of reasoning is not characteristic of a parrot.

However distressing the reaction of such a student may be, the instructor who educates is compensated by the reaction of the interested and industrious student, especially when he volunteers ideas or asks questions that are related to subject matter scheduled to be presented subsequently. The enthusiasm of such a student stems from the discovery that he too can be logical and capable of independent reasoning. Even more gratifying are the questions for which science, as far as the instructor is aware, has not yet provided answers. The instructor who has never experienced the synergistic effects of such questions on his own ability to think and provide satisfying answers, may be a masterful inculcator, but something less as an educator.

A scholarly presentation of the chemistry of organic medicinal products should provide a basis for the integration of the heterogeneous facts and principles presented by other departments, for correlation of the known with the assumed, and for inspiration of original thought in the broad vistas of the unknown. In other words, a student should be given a working knowledge suitable in dealing not only with the commonplace problems facing a pharmacist but also with the new and unusual problems appearing with increasing frequency in the expanding pharmaceutical technology of today.

The facts and principles guiding pharmaceutical technology are most numerous and heterogeneous. A pharmaceutical problem may require for solution knowledge of a drug that may fall in any of a number of categories: e.g., nomenclature, physical properties, chemical properties, and pharmacologic properties. A student who has benefited from four years of pharmaceutical inculcation may provide a quick answer to a question concerning the amount of propylene glycol in hydrophilic ointment. He may pause

a little in suggesting a substitute for the propylene glycol in hydrophilic ointment. He may be willing only to hazard a guess if asked the reason for the presence of 12 per cent propylene glycol in hydrophilic ointment. On the other hand, the educated student might find it necessary to refer to the U.S.P. in answering the first question. However, if his knowledge of nomenclature, classification, chemical properties, physical properties, and pharmacologic properties of propylene glycol has been properly correlated, his reflections in part will deal with the humectant action of propylene glycol in stabilizing oil-in-water emulsions, the relative humectant properties of other polyhydric alcohols, and the acceptability of other alcohols as substitutes for propylene glycol after consideration of their other physical, chemical, and pharmacologic properties. There are many aspects to this pharmaceutical problem with which the educated pharmacist can deal intelligently; and, what is more important, he is not blissfully ignorant of the many aspects of the problem. In all likelihood he will be able to solve the problem without creating new problems.

In a course in the chemistry of organic medicinal products, the instructor has an excellent opportunity to make the student's knowledge adaptable to the solution of many problems, especially important being those new problems which are likely to arise concurrently with future developments in the medical sciences. The student's knowledge becomes thus adaptable when correlation is established among the chemical, physical and pharmacologic components of his knowledge of drugs. Opinion varies somewhat as regards the optimum basis for this correlation. If all other factors are correlated with pharmacologic properties and a pharmacologic classification is employed, some instructors will find it difficult to give a course which differs in a fundamental way from a course in general pharmacology. Such limitations are evident in textbooks with an approach of this kind. Probably more emphasis is given to chemical constitution and, when the members of a given pharmacologic class seem to have physical properties in common, the physical properties may be considered. A discussion of chemical properties and syntheses appears somewhat incongruous with the bulk of the text and seems to have been inserted partly to justify the word "chemistry" in the title. Actually, there is little correlation between chemical properties and pharmacologic properties in many cases, e.g., general anesthetics; and the same applies to physical properties and pharmacologic properties in many other cases, e.g., local anti-infective agents. If both the physical properties and the pharmacologic properties are known, deductive reasoning cannot lead to intelligent conclusions concerning chemical properties, and a separate dogmatic presentation of facts concerning chemical properties becomes necessary.

A classification based on pharmacologic properties with which all other information may be correlated, while somewhat more useful, suffers from the same type of limitations that would characterize a classification of drugs according to their ability to undergo substitution with nitrous acid or some other chemical property. Neither pharmacologic properties nor chemical properties are sufficiently fundamental to provide a basis for deduction of a maximum of other facts required for the intelligent handling of drugs.

Probably the most fundamental aspect of a drug is its structural formula. From this, intelligent deductions can be made concerning chemical properties: e.g., qualitative identification, quantitative determination, solubility which depends on coordination of the neutralization type, synthesis and use as a starting material in the syntheses of other substances. The structural formula also implies a great deal about physical properties and, in teaching the chemistry of organic medicinal products, the instructor may find it desirable to supplement what the student already knows about the effects of homology and isomerism on transition points and solubility, the physical effects of hydrogen-bonding and chelation, the solubilizing effects of certain groupings, the chromophoric effects of structural features in determining color and spectra, the somewhat additive effects of atomic groups and linkages in determining such constants as molecular refraction, molecular volume, etc., and the role of polar and nonpolar groups in determining the behavior of substances at an interface. The rather confusing array of substances used as surface-active agents can be resolved by a proper correlation of structure and physical properties, and reasonable deductions can be made as regards preparation and use of new agents of this type. Nomenclature which is based on any aspect of a drug other than the structural formula, if not completely arbitrary, is subject to considerable limitations and, frequently, ambiguous misinterpretations. Most of the drugs obtained from the adrenal glands have properties quite different from those of Adrenaline. The name Procaine is definitive of only a few properties shared by Cocaine and 2-diethylaminoethyl p-aminobenzoate. It is something less than flattering to the male migraine patient when he is treated with Gynergen. The importance of the relationship between structure and pharmacologic properties for the intelligent handling of drugs needs no elaboration since it receives emphasis in all courses of this type, regardless of the classification employed.

The most useful knowledge of organic medicinal products is that which has been integrated about structural formulas. The instructor, in presenting lectures, assigning reading and problems and giving examinations, should strive objectively to emphasize the importance of the correlation of structure with nomenclature, the correlation of structure with pharmacologic properties, the correlation of

structure with physical properties, and, finally, time permitting, the correlation of structure with chemical properties. A simple axiom, together with a little reflection, will show that knowledge of the relationships between structure and physical properties on the one hand and the relationships between structure and pharmacologic properties on the other hand is a basis for intelligent deductions concerning the relationship between physical properties and pharmacologic properties.

A structural classification in which a high degree of autonomy has been assigned to acyclic, isocyclic, and heterocyclic systems is unwarranted, especially from the standpoint of pharmacologic properties; the same objection applies to rigid distinctions between substances according to their degree of aromaticity. The latter distinction between organic substances is merely a quantitative one, a traditional hangover from the time when the compounds known were limited in number and could be grouped into one class possessing a low degree of aromaticity (aliphatic compounds) and another class possessing a high degree of aromaticity (aromatic compounds). Classification according to aromaticity does not have a fundamental structural basis, but depends primarily on consideration of chemical properties. The structural difference between N-methyl-cyclohexylisopropylamine or Benzedrex (classically an aliphatic compound) and N-methyl-phenylisopropylamine or Methamphetamine (classically an aromatic compound) does not justify the appearance of these compounds in different structural classes, and the same may be said concerning their classification pharmacologically.

In the classification of drugs, distinctions between acyclic, isocyclic, and heterocyclic compounds likewise result in lack of association of substances with similar chemical, physical, and pharmacologic properties, even though there is a true structural basis for distinction between these types of compounds. For example, when such distinctions are made in classification of drugs, Methadone falls in a class far removed from the class in which Morphine and Demerole appear. The fact that the amino nitrogen is part of a cycle or a chain substituent does not have a fundamental effect on the pharmacologic, physical, and chemical properties of the substances. Moreover, it is desirable to discuss at the same time the naturally occurring substance which is frequently alkaloidal and heterocyclic, and the synthetic analog which is frequently acyclic or isocyclic. Such is the case with Cocaine and Procaine, Morphine and Methadone, Papaverine and Trasentin, Physostigmine and Neostigmine, and many others.

A functional group-derivative type of classification has been used in certain textbooks on the chemistry of organic medicinal products. Such a classification, if judiciously employed, makes possible a certain degree of correlation of structure with nomenclature and the pharmacologic, physical, and chemical properties of drugs. A principle of latest position should be followed in dealing with compounds having two or more dissimilar functional groups, and such is the case in the aforementioned textbooks. For example, amino-alcohols should be a subclass under amines, and therefore should be studied after the pharmaceutical chemistry of alcohols and amines has been taken up. The same consideration applies to derivatives: Diethyl Ether should be considered as a member of a subclass under alcohols; Anethole in a subclass under phenols; and Acetophenetidin in a subclass under amines. Unless the derivative is subordinated to the functional group parents in the classification scheme, considerable reiteration of material presented in connection with the parent substances becomes necessary in dealing with the derivatives. Consideration of Acetylsalicylic Acid, Phenyl Salicylate, and a number of related compounds in conjunction with Salicylic Acid provides a better basis for association of ideas than consideration of the various substances under different headings.

The inadequacy of the classifications of drugs according to structure that are in current use is indicated by the occurrence of drugs with similar pharmacologic properties in different structural classes. Pharmacologic properties depend on the same structural characteristics which determine chemical properties and physical properties; hence the inadequacy is not one of a structural classification as such, but results rather from incorrect specifications either of the structural classes or of the pharmacologic properties. For example, in the classification of sympathomimetic amines, considerable emphasis is sometimes given to the order of the amino group, with the result that Amphetamine is considered under the heading primary amines and Methamphetamine under secondary amines. What could have been said about both must be repeated to some extent when each is taken up under separate headings, and the pedagogical value of comparison is, to a large extent, lost. Since it is possible that metabolic transformations may well eliminate these structural differences, a different structural classification of these substances may be desirable. Both compounds will occur in a structural class labeled phenylalkylamines, specifically, phenylisopropylamines, along with other compounds which, to a surprising degree, have similar pharmacologic properties. A similar situation exists in classifying the phenylalkanolamines: the parallel between the structural classification and pharmacologic classification is recognized when Epinephrine, Arterenol, and Phenylephrine appear in the subclass phenylethanolamines, and Ephedrine, Propadrine, and related compounds appear in the subclass phenylisopropanolamines.

If specifications for the structural classes have been drawn correctly, it may be possible to avoid pharmacologic, physical, and chemical dissimilar-

ities among the members of a class. Moreover, since many of the substances used as drugs have a number and generally a variety of functional groups, it may be expected that the structural classification of drugs will not parallel a structural classification of organic compounds in general. For example, carboxylic acids as a class of drugs have relatively minor importance when compared with alpha-aminocarboxylic acids; polyhydroxyaldehydes and polyhydroxyketones are of far greater interest in pharmaceutical chemistry than aldehydes or ketones as such. Knowledge of the structure and the resolution of compounds into well-defined pharmacologic types has, in most cases, not progressed to the point where it is possible to set up a classification scheme in which the members of a class are pharmacologically homogeneous. For the same reasons, pharmacologically similar compounds frequently fall into different structural classes. For example, Isopropylarterenol, a vaso-depressor, is in the same class of phenylethanolamines as the pressor agents, Epinephrine, Arterenol, and Phenylephrine, unless some qualification concerning the N-alkyl group is made in setting up specifications for this particular structural class. Benzedrex and Methamphetamine, on the other hand, will probably fall into different structural classes as far as present knowledge of structure and its pharmacologic significance is concerned. The contradictory appearance of pharmacologically similar compounds in different structural classes should, however, be welcomed as a beginning for inquiry rather than condemned as a sign of error.

Until discrepancies of this type can be straightened out, it will be necessary to employ various artifices in order to make the classification useful for pharmaceutical purposes. When pharmacologically dissimilar compounds occur in the same structural class, it may be expedient to subdivide the class in accordance with pharmacologic specifications. For example, amino-alcohol esters should be further classified as follows: cholinergic amino-alcohol esters (Acetylcholine, Carbachol, Methacholine, Bethanecol, etc.); anticholinergic amino-alcohol esters (Dibutoline, Atropine, Scopolamine, etc.); spasmolytic amino-alcohol esters (Trasentin, Pavatrine, Banthine, Panparnit, etc.); and locally anesthetic amino-alcohol esters (Cocaine, Piperocaine, Surfacaine, Procaine, etc.).

In order to overcome difficulties arising from the presence of pharmacologically similar compounds in different structural classes, it may be expedient to select one type of compound as the prototype for a given character of pharmacologic activity, and to reserve a detailed discussion of pharmacologic properties of all the compounds until the structural class containing the prototype is considered. For example, the structure, physical properties, and chemical properties of Diethylstilbestrol should be considered when the compound is taken up in the structural class, phenols. Aside from a brief mention of its estrogenic properties at this point, complete discussion of its pharmacologic properties should be deferred until hydroxy-ketones, the structural class of Estrone, the estrogen prototype, are considered.

The artifices suggested for resolving discrepancies between structural and pharmacologic classifications may, of course, be avoided by employing a purely pharmacologic classification in the first place, but only at a sacrifice of the opportunity to establish the correlations of structure with nomenclature, physical properties, and chemical properties. It would be a serious tax on the memory of the student if the pertinent points about the chemical properties of Cyclopropane, Ethylene, Chloroform, and Ether were discussed under a single heading, general anesthetics.

A rather simple test for judging the educational merits of various classification systems would be a comparison of the information deducible from the knowledge of the structural class of a compound and that deducible from the knowledge of the pharmacologic class of a compound. The knowledge that a drug is an analeptic should imply certain other facts about that drug; the same is true of the knowledge that a drug is a phenylisopropylamine. The fact that a drug is an analeptic, together with the information that may be implied from that fact, should be sufficient for the solution of many problems, especially those facing a physician. On the other hand, a pharmacist may make greater use of the knowledge that a drug is a phenylisopropylamine.

In presenting this discussion, it has not been the intention to make or imply any comparison between the relative importance of knowledge of chemistry and knowledge of pharmacology in meeting the problems of pharmaceutical technology. The relative importance of chemical and pharmacologic information will depend a great deal on the particular problem. Furthermore, the frequency with which problems occur which require for solution more pharmacology than chemistry or vice versa, would probably be different in each individual's experience. The simultaneous consideration of the same problem by a pharmacologist and by a chemist is possible only in the more affluent research institutions, and even then it is difficult to appraise equitably the relative value of their separate contributions to the solution of the problem. Such teamwork in solution of problems is effective to the degree that each member appreciates the scope and limitations of the other's philosophy. A liaison of ideas of both types will probably be characteristic of the chemical pharmacologist or the pharmacologic chemist or, if the challenge is met effectively, of the pharmaceutical chemist.

The true value of the borderline position of pharmaceutical chemistry should be recognized, and aspirations toward a high degree of autonomy of this science on either the pharmacologic or chemical side of the border line should be discouraged.

Unlike the chemist, who knows primarily how to isolate, synthesize, or analyse a substance, and unlike the pharmacologist, who knows primarily what substance should be isolated, synthesized, or analyzed, the pharmaceutical chemist should be schooled in the disciplines that enable him to deal with both aspects of such problems. Knowledge of both fields should be integrated in courses in pharmaceutical chemistry in a way that is optimum for the training of this borderline scientist, whether a pharmacologic, a structural or, as advocated in this discussion, a combined approach be employed. The extent to which this integration is accomplished is a measure of the instructor's ability to educate and, when dealing with some students, of his courage as well.

LABORATORY WORK IN THE CHEMISTRY OF ORGANIC MEDICINAL PRODUCTS

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The need for laboratory instruction in the area of organic medicinal chemistry for undergraduate students is debatable. The administrators and faculties of our pharmacy schools are in disagreement on this issue. Many of our schools offer laboratory instruction of some kind, but only a small percentage require such discipline in conjunction with instruction in this area. Some schools offer laboratory instruction as an elective for undergraduate students. For the most part, however, laboratory work in medicinal chemistry is offered primarily to special and graduate students. At Purdue laboratory work in medicinal chemistry is offered only at the graduate level.

Later, I wish to express my views on the issue, but for the moment it appears appropriate to point out briefly the objectives, the scope, the nature, and particularly the problems associated with such a course. Differences of opinions as to the method of approach for the presentation of subject matter pertaining to organic products of pharmaceutical interest and importance make it difficult to be specific. Thus, I propose to discuss these topics in a general way. I hope that this approach may be of the greater interest to this group.

The utilization of laboratory exercises as an adjunct to the teaching of a course in the area of organic medicinal chemistry should have as its primary objectives (1) to aid the student in understanding and assimilating information presented in lecture, (2) to put into practice information discussed in the class room, (3) to correlate theory with practice, and (4) to teach laboratory technics. These objectives are essentially those of any laboratory course. In the area of organic medicinal chemistry, however, certain fundamental technics have been acquired previously in other chemistry courses and thus, to teach technics, in reality is to extend and to perfect previous training. In cases of deficiencies the teaching of technics may be important, but in a course of this nature it should not be the main goal.

The formulation of a syllabus for a laboratory course in medicinal chemistry should be governed by the nature of the course for which laboratory work is to serve as an adjunct. Examination of the curriculum of the many pharmacy schools brings to light the fact that the subject matter for a course dealing with organic products of pharmaceutical interest and importance is presented in several ways. The faculties of some schools make their presentation on the basis of physiological and chemotherapeutic action; that is, subject matter is presented under such topics as local anesthetics, sedatives and hypnotics, hormones, vitamins, and the like. By such a scheme a number of important pharmaceutical products cannot be advantageously grouped and discussed because such compounds lack physiological or chemotherapeutic action, or because there is insufficient material to make an interesting presentation. Thus, quite often such compounds are passed over in a course in which the scheme of presentation is so based. These items, however, in most cases are not overlooked but they are taken up in a different way, either in another course or as a part of another course or courses. A second approach is to present the course based on classical chemical classification. By such a scheme all products organic in nature are covered generally in one course. These differences in presentation call for varied syllabi if the laboratory work is to parallel the theory.

Irrespective of which type of presentation one follows the various exercises can be classified into two major groups, namely, physical and chemical. Physical exercises may include experiments dealing with boiling point and melting point determinations, purification by recrystallization, distillation or sublimation, solubility, optical rotation, refractive index, viscosity, pH, and the like. Chemical exercises may include experiments which may be characterized as follow: (a) a study of the chemical reactivity of certain classes of compounds, (b) qualitative tests for the detection and identification of impurities, (c) qualitative tests for the identification of medicinal products or for differentiation of certain compounds, and (d) the synthesis of medicinal products illustrating methods of preparation and/or particular chemical reactions or series of reactions.

The selection of and the emphasis placed upon a particular exercise should be governed by the type of training one wishes to impart to the student. A course in medicinal chemistry is not a fundamental course in the same sense as a basic course such as organic chemistry, but, it is, more or less, the application of fundamentals as applied to the profession. In this age in which there is so much to present, it is more of a problem to know what to leave out than to find exercises to keep a student occupied. It is no easy matter to make selections. It is very difficult to present to one group of students a laboratory

course in medicinal chemistry which will meet the needs of students majoring in various areas of pharmacy. The ideal situation would be to separate the student body into groups according to their interests and design the exercises to meet the training needed for each particular area of specialization. In our pharmacy schools this seems to be impractical for handling all pharmacy students; therefore, one must resort to what appears to be the next best. This would be to set up exercises based on areas of specialization of the average student body. There is no point in setting up laboratory work to benefit only a few. At the expense of time and effort to the instructor students that need special attention or have other interests should be assigned special work. The supplementary work may be impractical in those schools in which the instructor carries a heavy teaching load and is assigned in addition administrative or committee duties. Under such conditions it is advisable to dispense with additional work, although the situation should be corrected to permit the instructor to give individual attention to the student.

Before expressing a view on the time to be allotted to the laboratory work in terms of the number of physical and chemical exercises, one should define in a general way areas of interest. For our purpose one may separate arbitrarily the student body into two basic groups, namely, professional and scientific. In the professional group one may classify for convenience of discussion retail pharmacists, salesmen and detailmen, hospital pharmacists, and pharmacists in government service. In the scientific group one may include students who are preparing for positions which entail research, product development or formulation, pilot plant operation, various aspects of manufacturing, synthesis, and analytical and control work. While we all agree that individual interest within each group, professional or scientific, varies, yet fundamentally within a group all positions have much in common with regard to training. Obviously, then, the proportion of time to be allotted to physical and chemical exercises should be based on the training one wishes to impart to the greatest number of students enrolled in the course. Thus, if the largest number of students assigned to the course can be classified as belonging to the professional group then the physical aspect of organic medicinal chemistry would serve the greatest usefulness. A number of experiments on chemical identification would also be desirable but the synthesis of organic products should be held to a minimum. If the largest number of students assigned to the course can be classified as belonging to the scientific group then both physical and chemical aspects of organic medicinal chemistry would be highly desirable including approximately equal portions of both.

The choice of a particular exercise, whether it be of a physical or a chemical nature, should be left to the discretion of the instructor. To my knowledge, only one laboratory manual is available from which to select experiments which may serve as a guide. This is the Laboratory Manual of Organic Medicinal Products by Drs. W. H. Hartung, W. T. Sumerford, and M. F. W. Dunker. In this manual there is a sizable number of physical and chemical experiments from which to select or assign work for a course according to one's preference. Very little has been written on the subject. The best outline published with which I am familiar is that of Dr. Gisvold entitled "Laboratory Instruction in the Chemistry of Organic Medicinal Products." (1) While the author made no attempt to be specific in his outline, nevertheless, it might serve a very useful purpose for those teaching or setting up a course in this area. The outline is an expansion of that given in the "Pharmaceutical Syllabus" under the title "The Pharmacy of Medicinal Products" in the sense that it gives more details on the kinds of experiments that may be included in a course. With these two sources of information any one with training or teaching experience in pharmaceutical chemistry should have no difficulty in selecting particular exercises.

Now, let us turn to the controversial issue. Is a laboratory course in organic medicinal chemistry of such importance that it warrants a place in the curriculum or should it be replaced by some equally or more important course? As was mentioned before, the schools are divided on this issue. Those schools that require this discipline no doubt feel justified in this requirement while others feel there is no real need for it. There are certain arguments advanced by those who support or give laboratory instruction in this area. First, it is argued that laboratory instruction is an aid for studying and for the retention of factual knowledge. That is, this group feels that paralleling class-room instruction with laboratory work is a great help to the student in learning. By testing or synthesizing various medicinals the student learns first hand about their physical and chemical properties and how these substances are prepared. Those that disapprove of these contentions argue that the time spent in the laboratory could be more profitably used by instruction with visual aids, demonstrations, or recitations or a combination of two or more of these methods. This group argues that in terms of hours spent in the laboratory this method of teaching in this particular area is ineffective and inefficient. Second, there are those that feel that laboratory exercises help to develop technic. As was pointed out before, fundamental technics should have been acquired in courses prerequisite to laboratory discipline in medicinal chemistry, and thus, instruction in this area should serve to develop further previously acquired skill. Irrespective of the nature of the exercises, they are essentially a further development of technic previously acquired in fundamental courses. For the professional group this discipline should be held to a minimum. Pharmacy as practiced today

does not require the technical skill that some would like us to believe. It is hard to justify this training for the professional group when the time could be utilized more profitably in the study of social and biological sciences. For those who wish to apply their training in a scientific way the arguments mentioned in favor of laboratory work are justifiable for other reasons.

Based on experience gained from teaching organic medicinal chemistry, with and without laboratory instruction, and from the knowledge gained from industrial and institutional experience I have reached certain conclusions relative to laboratory work in the area of organic medicinal chemistry. Personally, I see no great need for offering laboratory instruction to students who have been labelled professional. I am very reluctant to agree with any arguments which favor such laboratory work. I cannot see the practical or theoretical value of such instruction. If I were asked to give laboratory work in organic medicinal chemistry I would consider the physical and chemical aspects, excluding synthesis, the most plausible phase of instruction for the professional group. For the students labelled scientific and especially for those who plan to do graduate work I strongly advocate laboratory work the nature of which has been indicated already. I think these students need as much technic as they can acquire. These students need laboratory technic and practice since in their industrial or graduate work they will apply many of the principles and technics which they have been taught. These students need to develop confidence in the laboratory. This is generally acquired by spending hours in the laboratory doing things. The students of this group seem to be the most interested in and assimilate the most from laboratory work, and to this group the laboratory seems to serve the greatest usefulness. Since the number of students interested in advanced technical training in the pharmacy schools is greatly in the minority, I believe laboratory instruction in medicinal chemistry should be an elective course for undergraduate and special students and a highly recommended or possibly a compulsory course for students at the graduate level.

Reference

(1) Gisvold, Ole, Laboratory Instruction in the Chemistry of Organic Medicinal Products, Am. J. Pharm. Ed., 13, 309 (1946).

WHERE IS THE PHARMACY OF ORGANIC MEDICINALS TO BE TAUGHT?

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Before one can discuss where the pharmacy of organic medicinals should be taught, it might be best to determine what is the pharmacy of organic medicinals. It is a well-established fact that organic medicinals, as represented in the hundreds of official and nonofficial drugs and specialties, comprise the majority of prescriptions filled today. Each successive prescription survey indicates that the per cent of noncompounded prescriptions is constantly on the increase and that this trend shows little likelihood of being reversed. This pattern of prescribing should not be decried since the use of highly specific therapeutic agents is surely more scientific and more predictable in effect than the polypharmacy of bygone years. In those days ten to twenty ingredients were compounded into an elegant preparation but one which was often inert and rarely more than a palliative or a placebo. Pharmacists then took great delight in dispensing a clear sparkling liquid often accomplished by the simple expedient of filtration. The fact that the precipitate carried with it all activity disturbed them not a wit since they were totally ignorant of such a result and were in no position to predict it.

Because of the change in the nature of prescriptions in recent years, there are those in pharmacy who claim that the modern curriculum in pharmacy needs only a course in the use of manufacturers' price lists, a razor blade, and a typewriter, and that the balance of the time should be spent teaching students merchandizing methods and how to operate a super-market. If reactionary thinking such as this had prevailed in years past we would still have a two-year technician's course such as that given in the twenties. Pharmacy has still not recovered from its failure in those years to advance its standards in time and it may even today be making the same mistake.

The great error made by many in considering the scope and content of a course in pharmacy is the mistaken belief that the act of filling a prescription is the one and only objective to be met in training the student. It is indeed tragic that some few departments of pharmacy still subscribe to this short-sighted policy. When one visits such a department the drab lackluster teaching which one sees is immediately apparent as is the lack of motivation in both teacher and student.

Pharmacy in its proper perspective is the application of all basic sciences and professional subjects, insofar as the total duties and responsibilities of the pharmacist are concerned. The term pharmacist is used here in its broadest sense, not simply with reference to the pharmacist employed by, or operating, a retail drug store. It includes the pharmacist in a professional store, in industry, in government work, in the hospital, in public health work, and in all of the diverse areas where pharmacists serve. Surely when one teaches pharmacy he must do so with the realization that his students will enter all avenues of the profession and that relatively few will become employees of a merchandizing chain.

The pharmacist has many and varied responsibilities if he is to be a real expert on medicinals serving both his community and the related health professions. He is not simply a storekeeper but one upon whom the public can depend for sound advice in matters pertaining to their health needs. In the field of medicinals per se his knowledge should far surpass that of the medical practitioner. If it does not, he is failing in that one area where by common assent he can and should excel.

Pharmacy is an applied science as well as a profession and it might well be compared with clinical medicine. Here all of the disciplines previously studied are drawn upon in order to make a diagnosis and effect a cure. The teacher of pharmacy must be well grounded in chemistry and pharmacology and he must draw heavily upon these fields if he is to present his course effectively. In addition, he must frequently make excursions into the fields of physics, physiology, bacteriology, and pharmacognosy. The best teachers even inject some philosophy and ethics into their lectures and discussions.

It is this speaker's opinion that pharmacy should be divided into two parts. Dispensing pharmacy should concern itself with the manufacture of various types of preparations, the filling of prescriptions, and the study of incompatibilities. Considerable attention should also be given to the application of physico-chemical principles in the preparation of many products such as emulsions, lotions, ointments, ophthalmic solutions, and so forth. The newer pharmaceutical aids such as surfact-active agents, the polyethylene glycols, the cellulose ethers, and the like, should be incorporated. An entirely separate course titled "The Pharmacy and Chemistry of Medicinals" should also be given. Such a course should be taught on a high level, following the basic sciences. It should be presented with the objective of having the student become familiar with the chemical structure, properties, pharmacology, uses, dosage forms

available and their preparation, contraindications, and side-reactions and should embrace the whole field of medicinals. The relationship of chemical structure and activity should be pointed out and the advantages and disadvantages of related or competitive products should be discussed. Such a course must not be restricted to official drugs and the teacher, if he is to do the job well, must even keep ahead of products already released and discuss products still in the investigative stage. The students of today are the practitioners of tomorrow, and this fact should never be overlooked. It is tomorrow's pharmacy which we must teach today.

A course such as that described is being given in an increasing number of colleges, and it has been enthusiastically received by students. It is still more strongly endorsed and appreciated after students have graduated and entered practice. Even the old die-hards in practice grudgingly concede the value of such training. A pharmacist so trained is in truth the expert, which he should be, in the selection and use of drugs. The medical profession is today in desperate need of such drug experts for the average physician is completely confused by the plethora of drugs with which he is confronted, and yet without them he cannot practice. The question now arises, By whom should this course be taught? Chemists will claim that chemistry is the real meat of such a course; pharmacologists will make a similar claim. While this speaker admits prejudice, he feels that the pharmacy department should present such a course rather than the department of anatomy or that of pharmacology, just as the department of medicine presents clinical medicine in a medical school. If is unfortunate, however, that some departments of pharmacy have chosen to default on this issue and by failing to meet the challenge of changing times still teach little in their pharmacy courses except the making of galenicals and prescription filling. Where, in such cases, the chemistry department has filled the vacuum they should be thanked and not criticized. Graduates of colleges would be seriously handicapped had not this most important part of their training been given by someone.

The real criterion in deciding where the pharmacy of organic medicinals is to be taught is finding a man with the proper background and training who will dedicate himself to the tremendous task of keeping constantly abreast of the rapidly changing field of medicinals. He must not content himself with the drugs of the U. S. P., the N. F. and and the N. N. R., but he must keep "living" notes changed daily on the basis of extensive reading in the current literature. Such a teacher must be well grounded in both chemistry and pharmacology and it is particularly helpful if he is also a pharmacist. He should teach little or nothing else, for this is a task the magnitude of which is known only to those who do it and do it well.

The reward for such dedicated teaching is great indeed for such a teacher can see that he is making a significant contribution in helping place pharmacy on that professional level where it can truthfully be called a full partner of medicine and not its servant. This is the status which the true educator in pharmacy sets as his objective. To be satisfied with anything less is to betray the trust placed in us and be unworthy of our calling as teachers.

RECENT DEVELOPMENTS IN ANALYTICAL CHEMISTRY

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As our knowledge of the science of chemistry increases, the task of describing these new developments becomes more complex and serves to impress upon the individual who is attempting to stay abreast of these advancements the fact that great progress has been made and is today being made in all phases of analytical chemistry.

Any attempt that I might make to group or classify the many approaches that an analytical chemist may have to a specific problem would undoubtedly differ from classifications made by many of you here tonight. In order to organize my thinking, however, and to present a somewhat logical course for discussion I should like to refer to these so-called newer developments as "Instrumental Techniques."

The application of instrumental techniques of measuring various physical properties of specific elements and compounds when treated under rigidly controlled conditions has brought about a vast new field of interest to the analytical chemist.

For the express purpose of attempting to bring to you some of the newer approaches to these problems it seems desirable to classify these "Instrumental Techniques," in the following order:

I. Voltage Measurements

Under this heading one would group those methods which depend upon a change of electromotive force and the measurement of this change by some instrumental means.

A. The measurement of the pH of a particular substance is perhaps the simplest example one could choose to illustrate this type of instrumentation. However, the rigid control of the pH of various processes is of paramount importance.

A second type of voltage measurement is potentiometric titration.

B. Potentiometric titrations of acids and bases are of great value when one is faced with the problem of titrating colored solutions which mask the color change of the desired indicator. Potentiometric titrations are also of great value in the case of oxidation-reduction reactions in which there is no indicator which exhibits a color change at the desired potential.

From a research point of view this type of analysis can be very useful in determining the dissociation constants of a large group of organic substances which ionize in water or other polar solvents.

Nonaqueous titrations, a subject which is beginning to occupy more space in the literature and a technique which has many applications in the pharmaceutical field, would also be an example utilizing this type of instrumentation.

Dr. C. Morton, head of the Chelsea School of Pharmacy in England, has just published a very comprehensive review article on "Instruments Employed in Potentiometric Determinations" in the May, 1952 issue of the Journal of Pharmacy and Pharmacology. He discusses the various types of instruments, as the title implies, together with their application and what has been attempted in order that some of the troublesome spots, such as "errors due to grid currents," may be overcome. Some seventy or more references are cited, and it behoves anyone interested in potentiometric titrations to read this very comprehensive article.

C. Still a third type of voltage measurement is polarographic analysis, more recently referred to as amperometric analysis, which was originally devised by Professor J. Heyrovsky in Prague about thirty years ago. However, it has only been in the last ten years or so that polarography has been accepted for pharmaceutical analysis, and it now seems generally agreed that this technique warrants consideration of a permanent place among the complex equipment of a modern analytical laboratory.

In polarography the sample to be examined is dissolved in a base solution containing an excess of a base or supporting electrolyte and is placed in a special electrolytic cell, which has a pool of mercury as the anode and mercury dropping from a capillary at the rate of one drop every 2 to 4 seconds as the cathode. When a gradually increasing voltage is applied to the cell and the corresponding current is measured on a galvanometer, it is possible to determine from the resulting current-voltage curve both the nature and the concentration of the reducible substances in the sample.

If the dropping mercury electrode is made the anode, analytical data on oxidiz-

able substances may be obtained.

Under normal conditions, the accuracy of polarographic analysis is about ± 2 per cent in the concentration range between 10^{-3} and 10^{-4} molar and ± 5 per cent between 10^{-4} and 10^{-5} molar.

Polarography may be applied, in the pharmaceutical industry, to the determination of

1. Dissolved oxygen or peroxides
2. Trace metals and metal containing drugs
   Antimony, arsenic, copper, iron, lead, etc.
3. Antiseptics and insecticides
   Thimerosal
4. Vitamins
   B_1, B_2, C, and nicotinamide
5. Hormones
   Thyroxin and adrenaline
6. Antibiotics
   First nonbiological method for penicillin
7. Alkaloids
   Most alkaloids

Before leaving polarographic methods, I should like to cite a current review article by Dr. J. E. Page of the Glaxo Laboratories which appeared in a very recent issue of the aforementioned Journal of Pharmacy and Pharmacology.

II. Electro-Deposition Methods

The second group of methods that might be considered are those which would come under the heading of Electro-Deposition or Electrolytic Methods of Analysis. This type of analysis is particularly desirable for use by laboratories doing a great amount of nonferrous metal analysis; however, in addition to the nonferrous metal analysis the electrodeposition procedures are advantageously employed in the determination of metals in biological material, foods, and soils and in electroplating solutions of forensic materials.

These methods are now being used on micro and semimicro scales in addition to the normal analytical procedures.

There are available compact and useful electro-deposition units which minimize the time required by an analyst to complete the assembly and use of the desired apparatus. It is estimated that the newer type of electrodeposition units will reduce the time required for an analysis by about forty per cent, thus reducing over-all expenses and calling for much less manipulation by the analyst.

III. Fluorophotometric Analysis

Fluorometry is the measuring of the concentration of fluorescent substances by determining the intensity of the fluorescent light which they emit under standardized conditions.

In some cases the substance which is actually being assayed may not be a fluorescent substance, but may be converted into a fluorescent substance through suitable chemical procedures.

The intensity of the fluorescence depends on several factors, chief of which are:

1. Concentration of fluorescent substances in solutions
2. Intensity as well as wave length of the exciting light
3. Nature of fluorescent substance
4. Nature of solvent
5. pH and temperature of solution
6. Effect of interfering materials in the solution

In most fluorometric analyses the intensity of the fluorescent light emitted by a solution of unknown concentration is compared either directly or indirectly with the intensity of the fluorescent light emitted under similar conditions by the same substance in known concentrations.

The fluorophotometer is of great value in analyzing and standardizing solutions or preparations containing Vitamins A, B_1, B_2, B_6, C, E, Nicotinic Acid and many other substances.

IV. Spectrophotometric Analysis

By spectrophotometric analysis in generally meant the comparison, at a given wave length, of the intensity of radiation which emerges from an absorbing sample with the intensity of the beam as it enters the sample.

A word about the various instruments that might be used for this type of measurement is in order at this point.

There are certain essential features that any spectrophotometer must have.

1. A light source
2. A dispersing system
3. An optical train which includes a cell containing the colored sample and a second cell containing the reference substance
4. A device for comparing the intensities transmitted by the colored sample and the reference substances

In the visible and ultraviolet ranges of the spectra the instrument may be used as a quantitative instrumental measurement of the quantity of a specific substance in a given solution. In the infrared range the spectrophotometer is more useful for identification purposes than for exact quantitative measurement although several quantitative procedures are now in use. Perhaps one reason for this is the fact that neither photographic film nor photocells are as sensitive to infrared radiation. A thermocouple, which picks up the radiant energy and produces a potential proportionate to its result-

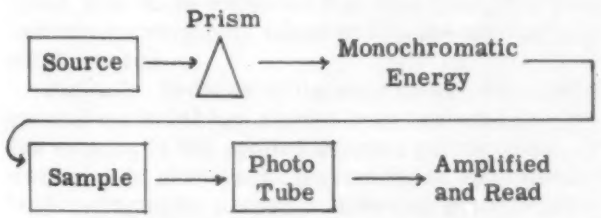
ing temperature rise, or a bolometer, the resistance of which increases with the resulting temperature rise, is generally employed to measure the radiation transmitted by the sample being examined.

Very briefly, the spectrophotometric method of analysis is applicable in general to the following types of problem:

1. Quantitative analysis of certain cations, anions, and organic groups in concentrations ranging from a few thousandths of a per cent in one or two cc.
2. Vitamin assay and qualitative and quantitative analysis of certain complex organic molecules
3. pH measurements, dissociation, reaction rate
4. Investigation of molecular structure
5. Preliminary to colorimetric analysis and analysis of mixtures

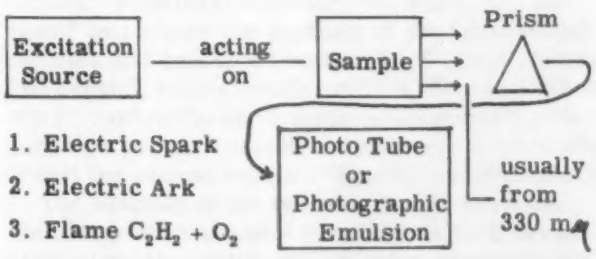
V. Spectroscopy

Fundamentally there are two types of spectrochemical methods - absorption spectroscopy and emission spectroscopy. Absorption spectroscopy deals with the measurement of the amount of monochromatic radiation which is either absorbed or transmitted through a sample, the sample being gas, liquid, or solid.



1. Hydrogen Tube - 200-400 mu.
2. Tungsten Bulb - 400-750 mu.
3. Glo Barr - 800mu - 20μ.

Emission spectroscopy is concerned, on the other hand, with the measurement of the intensity of a band of radiant energy emitted from an element (usually metal) after it has been excited by some device capable of producing emitted energy.



The Beckman Flame Spectrophotometer has become a very important and useful tool in the modern analytical laboratory and provides spectrochemical analysis to a limited extent at a reasonable cost.

VI. Chromatography

The extensive use of chromatography in so many unrelated fields of chemistry during the past several years serves to emphasize its present importance as a very important laboratory technique. There have been many reviews and comprehensive works dealing with its history, methods, and applications. Partridge from the University of Nottingham has just recently published quite a comprehensive review of the application of chromatography in pharmacy. He lists three types of analytical problems in which chromatographic methods are of particular value.

1. Tests for homogeneity of substances likely to be contaminated with chemically similar substances
2. Identification of pharmaceutical substances and preparations
3. Determination of individual components of complex mixtures, or of substances in dilute solution

Rigorous standardization of all the possible variables is of the greatest importance because of the frequently unpredictable effects of minor variations in chromatographic processes.

A technique that is generally considered closely related to chromatography is one which utilizes ion exchange resins to isolate either the desired constituent or the interfering constituents in a given sample. Subsequent measurement of the active component can then be made by either instrumental or chemical techniques.

It is very easy for one to become overenthusiastic about a given technique or method. This is particularly true if the major part of one's academic or industrial experience has been centered on a single approach to a given problem. There has been a tendency among some enthusiasts to be uncritical of a given technique and to use this procedure whether or not some other more satisfactory method exists. Whenever a new problem is being examined, all possible approaches should be considered, but before any method is adopted for routine use its merits must be compared with those of methods based on other analytical techniques.

The reliability of these new techniques will generally depend on two factors. One is the reliability of the instrumental measurements and the second is that of the chemical analysis forming the basis of the working curves. For in almost all cases spectral analysis is based on the results of chemical analysis in order to obtain the correlation of intensity data with the chemical composition of a sample.

Now I should like to cite an example of a product that has been utilized in pharmacy for as long as most of us care to remember, which has been official in either the United States Pharmacopoeia or the National Formulary for just as long, and which today still has no official assay procedure even though there have been published, over the last fifteen years, methods which employ many of the techniques mentioned here this evening. I am thinking of the mixture of acetylsalicylic acid, acetophenetidin, and caffeine.

The A.O.A.C. method depends on solubility separations and hydrolysis of the acetophenetidin to phenetidin sulfate. Holt, Green, Wilson, and Hilty have all made attempts to write a procedure, concerned with solvent separations, that could be universally used, but to date no one has succeeded in writing one which the present National Formulary Revision Committee would accept. In the meantime Kruger and his co-workers at Abbott, Parke, and various others at Lilly's have done a considerable amount of work in the Infrared spectrophotometric field, as have Jones and Thatcher in the ultraviolet region, and in the last few months Higuchi has come up with a method utilizing paper chromatography to separate phenacetin and caffeine.

It would appear that there certainly is progress being made in analytical chemistry as it particularly applies to Pharmacy and Pharmaceutical Products.

PHYSICAL CHEMISTRY COURSES FOR PHARMACY STUDENTS

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Of late the value of physical chemistry as a desirable fundamental course has become widely recognized in a great many fields. Progressive educators in such diverse applied sciences as medicine, agriculture, engineering, and pharmacy have attempted to include physical chemistry courses in their curriculums. The reason for this movement is obvious. As each scientific area grows older and approaches maturity, its core or center of gravity gradually moves over to the more fundamental, to the less empirical aspects of the particular science. Since by definition physical chemistry is that part of physical science primarily concerned with theoretical interpretation, rationalization, and prediction of behavior of chemical systems, it is to be expected that this discipline should become increasingly important to the applied scientific areas.

Actually, because of its very nature this fundamental material has always been included to varying extents in the applied science curriculums. For example, in pharmacy discussions of such topics as buffers, osmotic pressure, freezing point depression, properties of heat, solubility, rate of drug diffusion, equilibrium constants, colloid, emulsion and suspensions occupy a significant part of the curriculum in all schools. The recent proposals differ from the past and present practice only in formalizing the offering and in providing the material in a logical sequence with the necessary background.

In Pharmacy the curriculum committee of the AACP has recommended that the physical chemical approach to pharmacy be offered as two separate courses of one semester each. The first of these, entitled "Physical Chemistry for Pharmacy Students" introduces the students to the fundamental theories and concepts concerning chemical systems. The second, provisionally entitled "Physical Pharmacy" covers the application of these basic relationships to pharmaceutical systems. Some prefer to call the second course, "Theoretical Pharmacy."

The function of the basic course in physical chemistry is to acquaint the students with the theoretical relationships and concepts governing the behaviors of matter and energy. In a typical beginning course offered in a chemistry department the time distribution for various topics covered is approximately as follows:

	Per Cent
States of matter and solutions	25-30
The laws of thermodynamics and equilibrium	30-35
Kinetics and theory of reaction rate	10-15
Electrochemistry	15-20
Surface and colloid chemistry	5
Atomic and molecular structure	10

Since this distribution is based on a year course, it would obviously be a difficult task to squeeze all of the material into a semester course. It is my suggestion that it can be done if the subject matter of the introductory course is limited primarily to the first two basic items mentioned. This amount of material and a little more is normally covered during the first semester in the physical chemistry course offered by the chemistry department at Wisconsin. The feasibility of doing a good deal in a semester is demonstrated by the fact that in the College of Chemistry, University of California, the entire course was at one time and perhaps still is covered in one semester on a sophomore level.

Very broadly speaking, we note that these two items roughly represent the truly basic aspects of physical chemistry. The remaining topics are, in a sense, applications of the basic concepts developed previously to highly specialized areas. Although they represent very important and valuable scientific subjects, it is suggested that they should receive only cursory treatment in the first semester course to provide the necessary time for the basic materials. Such applications and specialized areas of primary importance to pharmacy are taken up in the second semester course.

If the physical chemistry course is to be offered at all to the pharmacy students, it is my opinion that the treatment of the basic material covered should be as fundamental and thorough as in the course given to the chemistry majors. The students, for example, should be provided with sufficient grasp of calculus to carry through and understand all of the necessary simple mathematical manipulations employed during the course. Mere exercises in substituting values into equations and formulae handed out by an instructor or found in a textbook certainly are of little value in helping the students grasp the fundamental relationships. The instructor

in such a course should provide the students with proper basic concepts so that they themselves can derive the required equations.

The beginning course in physical chemistry has developed a reputation, even among the chemistry majors, of being relatively a "tough" course. This viewpoint together with the horror generated in many people by the word "calculus" probably is responsible for the hesitant attitude exhibited by most schools of pharmacy towards introduction of the course. Actually, the mathematics employed in an introductory course in physical chemistry rarely goes beyond simple proportions and high-school algebra. In rare instances where calculus is employed, it is of the most elementary form with which even the poorest students have little trouble. The difficulty lies not with the mathematical operations but in translating physical facts into operations. A poor student for example knows from observation and from what he reads that the volume of a confined gas varies inversely as its pressure. Yet to calculate the volume, nearly one-half of the time he multiplies instead of divides with the pressure in the system. This sort of thing illustrates on one hand the futility of a purely descriptive course in this area and, on the other, the need for good and patient instructors for this subject.

The principal objective of the course in physical pharmacy is to introduce the students to the applications of basic physical concepts and relationships to pharmaceutical systems. An alternate and more practical function of this second course is to provide means of predicting the physical and chemical properties of unfamiliar drugs and formulations. Pharmacists have largely secondary interests in how a drug is made; their primary concern is in the properties of the drug itself: Will it dissolve in this solvent? Will it stand autoclavind? Can it be formulated with a particular ointment base? How can it be prepared as an isotonic solution? At what predicted pH will it be most stable? Can it be expected to be stable towards light? This area of thinking should be the forte of the pharmacists. Unfortunately, too few graduates from our schools are prepared to practice pharmacy along this line.

Although certain advanced theoretical topics of particular concern to pharmaceutical systems are taken up in the physical pharmacy course, the bulk of the course consists of simple, direct applications of relationships already learned. This is evident in the following suggested outline of the course:

I. Structure of matter
II. Homogeneous systems
    A. Properties of solution
    B. Buffer solutions
    C. Osmotic pressure and isotonicity
III. Heterogeneous systems
    A. Phase rule
    B. Solubility of drugs
        1. Solvent-solute relationship
        2. Influence of pH
    C. Partition coefficient
IV. Kinetics of drug deterioration
    A. Molecular process
    B. Free radical mechanisms
    C. Photochemical mechanisms
V. Colloid, emulsion, and suspension

Under "Structure of Matter" the embryo pharmacists try to correlate diverse physical properties of drugs, such as melting point, solubility, vapor pressure, and hardness, with their chemical make-up. Here they are introduced to various molecular, ionic, and atomic forces and the part these forces play in fixing the physical constants of drugs.

Energy and equilibrium relationships in homogeneous systems of particular pharmaceutical value are taken up under the next major heading. After a brief introduction to general properties of solutions, the students learn of buffer systems composed of one, two, and even more weak electrolytes. The fundamental relationships involved in isotonic solutions are also discussed in this section.

Under "Heterogeneous Systems" all systems containing more than one phase are treated. The students are first introduced to phase rule illustrated with pharmaceutical examples. Solubility behaviors of drugs including the influence of salts, alcohol, and pH on drug solubility are then discussed. Finally relationships governing partitioning of drugs between two phases are brought out.

"Kinetics of Drug Deterioration" is a topic of major importance to practicing pharmacists but is a subject which is rarely discussed in class on a fundamental level. Recent research attempts in various fields have provided sufficient basic material to approach this subject in an elementary but systematic fashion. The students in this section should be exposed to the basic theories of chemical kinetics together with conclusions which can be drawn by their application to pharmaceutical systems. The subheadings listed in this section represent the more important mechanisms by which a drug might lose its activity.

Since the last topic listed, "Colloid, Emulsion, and Suspension," has been amply discussed on a number of previous occasions, no time is taken at this time to spell out the material to be treated under this heading. It suffices to say that it has been proposed by some that a semester course be given devoted to this topic alone.

Physical pharmacy as a course needs no defense. It is a fundamental course offering the firmest base on which to build all modern professional courses in pharmacy.

INSTRUMENTATION IN PHARMACEUTICAL CHEMISTRY

Frank M. Goyan, L. A. Strait, and L. D. Tuck

About the time of the appearance of Wildhack's paper pointing out the emergence of the new science of instrumentation (1) several members of the faculty of the University of California College of Pharmacy suggested the desirability of developing courses on this subject designed primarily to meet the needs of graduate students in pharmaceutical chemistry. Recently the authors began an informal series of weekly conferences for the purpose of making definite plans for the announcements of elective courses in this general subject. This paper presents the results of those deliberations together with the experience gained in teaching the use of a wide variety of instruments to graduate and undergraduate students.

A broad survey of the field convinced the authors that students taking courses designed to cover the use of instruments as a separate topic will be benefited most by the presentation of the fundamental physical concepts involved in the applications of instrumental measurements. Further development of this idea led to the conclusion that a course designed for students engaged in pharmaceutical chemistry would not differ significantly from one designed for students engaged in other related fields of study. This type of presentation, however, presumes that the students have an adequate preparation in elementary physics and mathematics. Students who elect pharmaceutical chemistry very often do so because of lack of interest in these background subjects, and for this reason it seemed desirable to develop two courses, one at the graduate level for students who were adequately prepared and motivated, and another at the undergraduate level which may be taken as an elective by students of pharmacy as well as by students of pharmaceutical chemistry. The undergraduate course has also been planned with the idea that it may serve as an alternate prerequisite for the graduate course.

Modern instrumentation is essentially an outgrowth of the last war, or rather of the extensive research and development work stimulated thereby. Experts in several fields of science were often able to co-operate with surprising facility in meeting totally new demands for special instruments. In such development work a specialist might contribute the discovery of a detecting or sensing device which changed in electrical, mechanical, optical, or other easily measured property when exposed to changes more difficult to detect or measure. Methods for amplifying the response of the sensing device and for using the resulting amplified signal for detection, measurement, recording, and even the control of the phenomenon under consideration soon became standardized. With this standardization came the concept of planning new instruments and redesigning old ones by combining existing standard components.

This modern concept offers advantages in teaching the use of instruments in pharmaceutical chemistry. The principle advantage is that it is possible to cover a wide range of instruments with a minimum of repetition while focusing attention for each instrument studied on the underlying principles involved. In order to emphasize this phase of the subject, the two new courses discussed below are described in the College Bulletin as dealing with physical measurements rather than with instrumentation. It is clearly understood, however, that these courses will be designed to develop the student's ability to make practical use of physical instruments in solving problems in pharmaceutical chemistry.

The Undergraduate Course

The course planned for undergraduate students will be taught at a level which will be understood by anyone who has completed the usual courses in general college physics and elementary physical and analytical chemistry. The course has for its primary objective a bridging of the gap which exists in most curriculums between elementary physics and the practical application of physical principles to exact laboratory measurements. The secondary objective, which is expected to follow automatically if the primary objective is achieved, is to develop a confident understanding of the principle of operation of the usual laboratory instruments. With this understanding will come sound scientific judgment which will enable the student to evaluate new instruments and make sound decisions concerning the selection of instruments in practical laboratory work. It is obvious that such understanding and judgment will be of value to many practicing pharmacists who have occasion to consult with directors of clinical laboratories as well as to all students who plan to continue in the field of pharmaceutical chemistry or to enter the field of manufacturing pharmacy or food and drug analysis. It is felt that time is not allotted to the usual courses in physics or physical chemistry in order to enable instructors to cover this type of material adequately.

The present plan is to develop the course in two lectures and one laboratory session per week. The authors plan to present the lectures and laboratories

as a co-operative enterprise rather than to assign sections of the work to each instructor. It would be a mistake to underestimate the difficulty of presenting a sound course in this subject.

Teaching Techniques at the Undergraduate Level

In general it is planned to develop lectures around fundamental topics usually presented in college physics. These topics must be carefully selected and arranged so as to cover the principles involved in all of the instruments of general interest. Because most of the students who take this course will not have developed their ability in mathematics to the point where they can use mathematics descriptively (as contrasted with mathematics as a technique for problem solving), it will be necessary to illustrate the lectures by the free use of simple demonstrations.

Lecture demonstrations are difficult to present in such a way as to be of great value. There is danger of diverting attention from the fundamental ideas by putting on a good show. Every care must be exercised to avoid misplaced showmanship and at the same time to develop demonstrations which are interesting and easily remembered and understood. For example, in discussing the spectrophotometer, it is necessary to use a conventional projector with a slide showing a single slit which can be projected on the screen. The introduction of a prism or diffraction grating into the optical path produces a spectrum which can be shifted to the screen so that the light absorption of colored solutions can be shown directly. A projection photometer completes the equipment so that, essentially, the entire class is seated in a huge improvised spectrophotometer. Other demonstrations are planned along the same lines. The essential principle is to show the most elementary components of instruments as separate units, discuss them in terms of basic physics, and then combine them so as to illustrate the construction of standard laboratory instruments.

The laboratory period of approximately three hours per week is planned to provide the students with an opportunity to use as many instruments as possible. Instruments will be selected weekly with the idea of illustrating lecture material. Illustrative samples for study and primary standards will also be made available. It is hoped that it will be possible to secure the co-operation of all concerned so that sales representatives may be invited to add to the collection of available instruments by loaning demonstration equipment. Students will be given the opportunity to make routine service adjustments such as replacing batteries, adjusting zero settings, and so forth. They will also be required to make measurements on samples provided. It has been found that a group of intelligent students responds better to the challenge of comparing results for the purpose of arriving at a true value than to the more conventional challenge of reporting an unknown to the instructor. The former method has the advantage that it eliminates the delay usually necessary in reporting to an instructor, thus permitting a student to repeat a measurement at once if his results fail to agree with others. The minor disadvantage of this method is that the instructor has no very sure method of grading laboratory work, but this deficiency can be overcome to a large extent by frequent written tests based upon the fundamentals of the laboratory procedures.

A list of instruments is presented below for the purpose of illustrating the type of material likely to be covered. An exhaustive list would include several times as many items, including many elementary components. In addition, much of the lecture demonstration equipment will be placed in the laboratory for the purpose of review. Each laboratory session will begin with the demonstration of the various detailed procedures by an instructor. Students will be encouraged to develop their own test of the reliability and usefulness of each instrument presented. The following slides are presented for the purpose of showing a few of the instruments to be studied:

1. A constant temperature bath showing its use in determining specific gravity with a pycnometer
2. A hydrophyl balance for the study of surface films (Cenco)
3. A melting point bar set up with a potentiometer. (Dennis melting point bar)
4. A nephelometer (an adaptation of the Pulfrich Gradation Photometer)
5. A pH meter of the potentiometer type assembled from component parts
6. A pH meter of the vacuum tube voltmeter type
7. A photofluormeter
8. A polarimeter
9. A refractometer of the Abbé type
10. A chainomatic specific gravity balance
11. A spectrophotometer
12. A tensiometer for surface tension measurements
13. An ultra microscope of the slit type
14. A viscometer (synchroelectric)

The Graduate Course

The course planned for graduate students will be presented at a level that will require a sound mathematical background or an unusual familiarity with physical instruments. Mathematics through differential and integral calculus will be required routinely as a prerequisite, but admission to the course should be limited to those students who show considerable interest in the applications of physics either from a theoretical point of view or as the result of a desire to make use of instrumental

methods in solving research problems of their own choosing. The primary objective of the course is to enable students to plan research programs involving instrumentation. Such an objective implies that the student will learn to use reference books and review articles (2, 3) with critical judgment. Furthermore, it is expected that students completing the course will be able to design special instruments when those that are commercially available prove to be inadequate. Ability to design instruments, however, should not be allowed to encourage the student to regard this type of activity as one of the primary objectives of the course. As stated above, the primary objective is to learn to plan research programs involving instrumentation so as to solve important research problems related to pharmaceutical chemistry.

The course is planned to include two lectures and one laboratory session per week. The lectures will describe instruments mathematically so as to show the exact relationship between the readings taken and the fundamental properties studied. The laboratory time (approximately three hours per week) will be devoted to visits to research laboratories where the scientists in charge of the equipment in actual use will be invited to demonstrate the activity of the laboratory. It is hoped that by this process all of the students in the course will make valuable contacts which will lead to later independent consultation and co-operative research.

Teaching Techniques at the Graduate Level

Any graduate course should begin in such a way that the student is immediately confronted with problems of active scientific interest. In the field of instrumentation it would be possible to discuss a large number of different applications of instrumental measurements to current research. After careful consideration, however, it was decided to begin the course by discussing the meaning of measurement from the operational point of view introduced by Bridgman (4). This approach is intended to develop a philosophical note that will encourage a research point of view. After this introduction, it is intended to follow the plan developed for the undergraduate course with the important exception that mathematical analysis and description will be substituted for lecture demonstrations. It is the opinion of the authors that it is very important to develop an intuitive "feel" for the subject of applied physics. While it is unlikely that mathematics will contribute much toward this objective at the undergraduate level, it is hoped that graduate students will be able to take a creative interest in the mathematical presentations. Such creative interest will lead to experimental calculations related to instrument design and will thus combine the necessary visualization with an analytical approach that should develop some ability in the field of instrument design.

The laboratory part of the course is the key to its success. Under the supervision of a scientist who has the ability to secure the co-operation and stimulate the interest of many different specialists, the entire staff will co-operate in giving the course. Each member of the staff who is responsible for research instruments will be invited to participate. The class will be divided into small groups, and a visiting schedule worked out so that research laboratories will not be overcrowded. A note of informal co-operation will be maintained so that each member of the staff participating in the program will have maximum freedom in the presentation of his own speciality. It is hoped that all members will find the time to set up recent examples of their current research work in such a way that each student has an opportunity to use the instruments in checking results. Naturally, every effort will be made to encourage the students to follow the measurements they have made through to the stage of final publishable values. Lecture schedules will also be kept as flexible as possible so as to provide an opportunity for each of the participating specialists to lecture to the entire group in the field of his interest.

At present it is hoped that the course can begin with a large number of different research instruments available. The spectrographic laboratory is in a position to demonstrate the use of emission spectroscopy in the ultraviolet region with a quartz prism spectrograph and absorption spectroscopy using ultraviolet and infrared instruments. Recording instruments will also be demonstrated, and at least one research spectrophotometer can be set up so that all of the graduate students will have the opportunity of making a few illustrative measurements. In the field of electrochemistry it will be possible to give some experience in the use of a recording type polarograph and a modern electrophoresis apparatus and to demonstrate the use of conductivity bridges, potentiometers, and so forth, in the solution of research problems. Instruments necessary for the study of dipole moments are available, and it is likely that the use of Warburg techniques may be introduced. It is also planned to study the electron microscope, the ultra centrifuge, and several other instruments in the same way.

Summary

A graduate and an undergraduate course in the field of physical measurements are described to show the authors' approach to the problem of teaching instrumentation to students of pharmaceutical chemistry. The courses are planned to emphasize fundamental principles so as to develop the student's scientific judgment when he is confronted with the problem of selecting and using instruments. At the graduate level this point of view is extended to

develop the ability to plan related research programs. The details of the plans show that the presentation of these courses will not be an easy task, but will require the co-operation of many competent scientists. A partial list of the instruments required also serves to emphasize the magnitude of the maintenance problem associated with their constant use by inexperienced operators.

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CO-ORDINATION OF THE COURSES IN PHARMACEUTICAL CHEMISTRY

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The primary purpose of this Teachers' Seminar on Pharmaceutical Chemistry is to improve the quality of instruction in our schools of pharmacy and the major attention properly should be devoted to how to teach and how to teach more effectively in giving instruction in the individual courses in chemistry and pharmaceutical chemistry. At the same time it seems appropriate to devote some time and attention to the larger picture and to take a look at how our instruction in pharmaceutical chemistry fits into the whole pattern of the pharmaceutical curriculum.

Perhaps a more suitable title or description of my discussion would be "The Need for Correlation and Integration of the Courses in Pharmaceutical Chemistry with the Other Courses in the Pharmaceutical Curriculum." Correlation may be defined for our purpose here as bringing into mutual or reciprocal relation one part to another part or one part to a whole, and integration may be defined as the formation of a whole from constituent parts. As used by experts in education (1) the term "vertical correlation" is applied to the proper arrangement in sequence of a group of related courses which are presented at different times in the curriculum while "integration" is the proper arrangement of courses which are presented at the same time in the curriculum and deal with the same subject matter but from different points of view. If we accept the definition of co-ordination as a state of harmonious adjustment then it follows that the proper correlation and integration of the course content and subject matter of our instruction in pharmaceutical chemistry with that of the other courses in the curriculum is bound to result in a well co-ordinated pharmaceutical curriculum.

Some may not like the choice of terms or definitions used here but, regardless of how the situation is described, it has been my observation that we could be concerned with the benefits which these terms imply, not only with regard to the relationships among our courses in pharmaceutical chemistry but also between the courses in pharmaceutical chemistry and the other courses in the curriculum. For too many years the favorite comment among some of our pharmaceutical friends has been, "Get rid of the dead wood in the curriculum." In recent years this has been one of the most frequently voiced alternatives to proposals to lengthen the educational program in pharmacy. And, unfortunately, the comment has not been abated in the least by the answer that the dead wood has been cleaned out and by the invitation to submit a bill of particulars on what dead wood may still remain in the present day curriculum of the average good school of pharmacy. But if these people should need a new criticism around which to rally, I fear that they might find it if they were to explore the lack of correlation and integration of courses and course content in the unco-ordinated curriculums of some of our schools.

The instruction that is provided in the individual courses in the curriculums of most of our schools may be very good when considered by itself and apart from the other courses. But if the instruction and subject matter in each of the individual courses were to be considered in its relationship to the other courses and to the curriculum as a whole, there probably would be found an obvious need for correlation and integration. The lack of such correlation and integration may lead to the serious consequence of presenting, out of its proper sequence, the more advanced or applied aspects of a subject before the basic and fundamental knowledge prerequisite to an understanding of the subject has been presented; it may lead to needless, boring (from the students' standpoint), and time consuming duplication of subject matter, unnecessary repetition and overlapping; and, what is more important, it may result in the complete omission of essential and important subject matter.

This is not meant to advocate that instruction should be uniform to the point of making all teachers on the staff conform to a set pattern and to a narrow pathway in their instruction; so long as teachers remain the individualists that they are this will not happen. In the final analysis the quality of instruction in any course is largely dependent upon the teacher. A suitable textbook may not be available or the laboratory and other physical facilities may be inadequate, but as long as the teacher furnishes the proper and necessary inspiration and motivation to the student good instruction will result despite the other factors. At the same time, however, the teacher should not have the mistaken notion that he is an individualist simply because of his ability and tendency to range far and wide in the subject matter of his particular course and to give his students a smattering of all aspects of all subjects in the few credits devoted to his course. Although individualism is to be encouraged rather than discouraged in the teacher, he should keep in mind at all times the proper relation-

ship of his course to the other courses in the curriculum. The good teacher will never be criticized in his efforts to co-operate with others who might be treating different aspects or different points of view of the same subject matter.

One of the major objectives in the academic training of a pharmacist should be the development in him of a broad familiarity with, and an understanding of, drugs as physical, chemical and physiological entities. (2) Supposedly, the reason for the inclusion of any applied course in the pharmaceutical curriculum, whether it be pharmacy, pharmaceutical chemistry, pharmacognosy, or pharmacology, is that the course helps in the achievement of this major objective. Although it would be difficult to pick out any two or more applied courses in the curriculum which do not have some relationship through use of the same subject matter it would appear that points of common interest or impingement in subject matter are found more frequently among those courses which have their foundations in both the physical and the biological sciences, namely, the courses in pharmacognosy, biochemistry, chemistry of organic medicinal products, and pharmacology; to a lesser extent, the courses in microbiology and dispensing pharmacy might also be listed. But it is among the first four courses that there seems to be the greatest need for correlation and integration of subject matter and they will serve as illustrations for the purposes of this discussion.

If we look back over the years at the way in which the curriculum was developed in a more or less haphazard, hit or miss fashion, with too little thought given to related courses as they were introduced, it is not surprising that we find lack of co-ordination in many of the present day curriculums. As recently as fifteen years ago, among the four courses in question, only pharmacognosy was recognized as a well defined and distinct discipline that was included in the curriculums of all schools of pharmacy and it was given universally by the traditional taxonomical and morphological approach. Pharmacology as such was unknown in the pharmacy curriculum but most schools were giving, without proper foundation in the basic biological sciences, an inadequate approach to it under the name of materia medica or pharmacognosy. Biochemistry was a required course in only a few schools and, for that matter, even one year ago was required in only about one-half of the schools (1), although some schools apparently give various aspects of biochemistry in one or more courses. The applied course in organic pharmaceutical chemistry, or chemistry of organic medicinal products, was barely getting a good start fifteen years ago and it has been only since that time that it, or a course of similar nature with a pharmacy title, has become a requirement in practically all of our schools.

With the introduction, during the ensuing period, of one or more of these courses at different times and with no two of them being introduced at the same time, it was only natural and understandable for the teacher of one of the new courses to draw upon the subject matter of the others in order to provide his students with a better foundation and a greater familiarity with his particular subject and a better understanding of it. Thus, the teacher of the chemistry of organic medicinal products, in the absence of required courses in biochemistry and pharmacology would furnish some of the essential background material of those disciplines in order to enable his students to better understand his explanations of the relationship between chemical structure and physiological activity. Likewise, the teacher of pharmacology, in the absence of required courses in biochemistry and organic pharmaceutical chemistry, would indulge in a similar practice in order for his students to better understand his particular subject. After all of these relatively new applied courses were finally included in the curriculum, the teachers concerned have not always informed themselves of the course content and have not acquired an understanding of the proper relationships among the four courses and their relationship to the curriculum as a whole. The result has been a sometimes chaotic order of arrangement and sequence of subject matter and instruction. And with the present day trend of instruction in pharmacognosy away from the traditional approach and toward a chemical, biochemical, or physiological approach to the subject, the problem is complicated even more.

As one of its many activities the Pharmaceutical Survey examined and analyzed the pharmaceutical curriculum during the past few years and, among other things, concerned itself with (a) the formulation of the objectives of pharmaceutical education, (b) the scientific and technical content of instruction that should be taught to attain the objectives, and (c) the principles of organizing a sound curriculum. In its exploration of the scientific and technical content of a program of instruction the Survey was assisted by six separate committees which were made up of teachers from various schools of pharmacy. These separate committees analyzed the situation in the six fields of the curriculum and made recommendations as to the courses that should be included together with an estimate of the time or credits required for the presentation of the courses. By and large these six committees did their jobs well - - perhaps too well since they came up with a recommended total curriculum of 128 credits of required scientific, technical, and professional courses, exclusive of general education subjects.

Let us look for a moment at the definitions, objectives, and scope of some of the courses in question. On Wednesday's program of this Seminar Dr. Lewis told us of the scope, objectives, and applications of the course in biochemistry and on Thursday's symposium attention was devoted to the objectives and scope of instruction in the course or courses devoted to organic pharmaceutical chemistry. At the risk

of boring you with repetition, but for the purpose of emphasis of the points I wish to make in this discussion, I would like to recall for you what the report of the Survey Committee on Physical Science and Mathematics had to say about these courses in 1948. (3) This Committee defined biochemistry as the chemistry of cell components and vital processes and their products. Among the objectives of the course it listed (a) understanding of the application of fundamental concepts to life processes, both normal and pathological; (b) knowledge of the composition and interrelationships of carbohydrates, proteins, and lipids and the role of enzymes, hormones, vitamins, and minerals in life processes; (c) ability to interpret pharmacodynamic action of drugs in terms of chemical principles; and (d) knowledge of principles and techniques of determining the metabolic fate of foods and the absorption, fate, and excretion of drugs. The Committee recommended a course of six credit hours to be given in the third year of the four year curriculum and emphasized that the course content should be coordinated and integrated with the subject matter of courses in pharmacognosy and pharmacology.

This same Committee described the instruction in the course on the Chemistry and Pharmacy of Medicinals as a correlated survey of medicinal and pharmaceutical products, including a study of their composition, constitution, chemical and physical properties, pharmaceutical behavior, pharmacological action, and therapeutic use. It listed among the objectives of such instruction (a) an understanding of chemical structure, pharmacological action, and pharmaceutical use of medicinals and the effect of modification of structure on the physiological, chemical, and pharmacological properties; (b) an appreciation of new developments in medicinals in the light of past experience; (c) ability to read and interpret nomenclature and evaluate the therapeutic claims of competing products with unrevealing trade names; and (d) recognition of potential incompatabilities and the ability to deal with them.

From the recommended scope and content of these two courses in biochemistry and in the chemistry of organic medicinal products, whether the latter be given in one comprehensive course or whether it be divided into separate courses in the chemistry of synthetic drugs and the chemistry of natural products, we can see innumerable opportunities for much duplication in such subjects as blood products, folic acid, vitamins, dicoumarol, and hormones. Such duplication is bound to occur unless the teacher of the chemistry of organic medicinal products keeps in mind that he is not giving a course in biochemistry or pharmacology and likewise unless the teachers of biochemistry and pharmacology remember that they are not teaching a course in the chemistry of organic medicinal products.

What about pharmacognosy? You may wonder why it should be mentioned in this discussion but I believe you will see that it also should be in the picture along with the other courses. In the foreword to its report in 1948 the Survey Committee on Pharmacognosy stated that the "relationships of pharmacognosy to other subjects of the pharmaceutical curriculum have been kept in mind constantly, first to make certain that this instruction shall not overlap unnecessarily the instruction in other fields, and second, that it shall assist in providing the best foundation for other subjects, such as pharmacy, pharmacology, and public health." (4)

Under definition and scope the Committee said: "Pharmacognosy as an applied science in the pharmaceutical curriculum deals with the production, processing, qualities, and general uses of products of biological origin having current medicinal and pharmaceutical importance. It is concerned with their biological history, physiology, and pathology, as well as problems of collection, processing and commerce. It is also concerned with constituents, extraction, microscopy, identification, preservation and protection of these products and includes their adaptation to pharmaceutical, medicinal, and public health uses. The subject includes a consideration of those synthetic substances that are related to products of biologic origin. . . .

"In current pharmacognosy, chemical, biological, physical, and microscopic methods are employed. The constituents of plant and animal substances and factors responsible for their synthesis and variation in the living organism are no less important than the identification of the substances. The purpose of this material is to link certain related synthetic structures with the evolution and action of plant and animal constituents. Such a relationship contributes to a better interpretation of the characteristics of many drug actions. In fact the chemical study of these materials now looms large in the subject of pharmacognosy."

Among other objectives of the instruction in Pharmacognosy the Committee listed (1) knowledge of the constituents of natural products and of their preparations as a basis for determining compatibility with other drugs; (2) knowledge of the pharmaceutic and therapeutic applications of natural products and their preparations as a foundation for specific instruction given in the courses in pharmacy and pharmacology; and (3) knowledge of the methods by which products of natural origin are evaluated and ability to apply these methods. "Many natural products are evaluated by physical, chemical, and biological assay methods. Such procedures are generally studied in other courses of the pharmaceutical curricula; they are applied in pharmacognosy."

For this course in pharmacognosy the Committee recommended eight semester hours, most appropriately placed in the third year of the four-year curriculum, to be preceded by fundamental courses in biology and organic chemistry, with bacteriology preceding or being taken concurrently.

After examination of the definition, scope, and

objectives of the instruction in pharmacognosy as set forth by this Committee, can anyone deny that there would be ample opportunity in the subject matter of such a course for duplication and anticipation of that covered in the courses in biochemistry and the chemistry of organic medicinal products, and even in the courses in pharmacology and drug assay? It should be pointed out that the views of the Committee represent the approach of the so-called modern school of pharmacognosists as opposed to the traditional approach. It is also quite pertinent to note that three of the four members of the Committee came from schools where biochemistry was not a required course in the curriculum. It is estimated (1) that probably not more than 10 per cent of the schools at the present time offer a course in pharmacognosy using this modern approach. But if this thinking is a pattern for the future, then very definitely pharmacognosy is in the picture in the need for correlation and integration of the courses in the curriculum.

With regard to this modern approach to pharmacognosy there has been much discussion of the chemical, biochemical, physiological, or pharmacological organization and classification of the subject matter; that should be of great interest to those who are responsible for the applied chemistry courses in the curriculum. Those who follow the chemical or biochemical approach reject the suggestion that they might be teaching chemistry and insist that "organic chemistry must be prerequisite to pharmacognosy when a chemical classification of the subject matter is used, otherwise the pharmacognosy teacher would be compelled to teach chemistry." (5) Yet when it is proposed to consider in the modern approach such subjects as the Krebs Cycle and its significance in the biosynthesis of carbohydrates, alkaloids and proteins, (6) no case is made for biochemistry as a prerequisite for such instruction. Likewise, when it is proposed to treat the antimalarial drug in pharmacognosy, using the cinchona alkaloids as examples of natural products on the one hand and plasmochin, atebrin, and so forth as examples of synthetic analogs on the other, and taking up the chemical nature of those which possess characteristics in common, (6) apparently little thought has been given to how this subject matter overlaps and duplicates that which is covered in the course in the chemistry of organic medicinal products.

In fact, one gains the impression that the applied courses in chemistry that are in the curriculum do not seem to have a place at all in the thinking of the modern school of pharmacognosy when he reads such statements as, "The present status of pharmacognosy . . . . . is based upon teaching certain principles (chemical, physical and biological) and facts with which a pharmacy student may better learn the significance and importance of certain substances obtained from plants and animals."(7)

Others have pointed out that, as a prerequisite for pharmacology, the traditional pharmacognosy courses might be modified to contribute toward the achievement of an adequate background in the chemistry of natural products and in basic biological sciences which would enable the pharmacy student to think along physiological and biochemical lines. (8) Here again it would seem that little consideration has been given to the objectives of the applied chemistry courses in the curriculum.

The only reason we have a professional curriculum for pharmacy students is to develop in them that broad familiarity with, and understanding of, drugs which is essential to their successful practice of the profession. And the only reason for the applied courses in the curriculum, regardless of their nature, is for the purpose of giving the particular pharmaceutical slant and viewpoint to the subject matter that is presented. Deno (1) has shown how this can be accomplished in the presentation of what the pharmacy student should know about cortisone and has pointed out how all of the various aspects of this subject can be handled by proper correlation and integration of the various courses that might touch upon cortisone. The same thing can be and must be done for any number of items, including the hormones, the enzymes, the cardiac glycosides, the vitamins, and many others. Another illustration might be given in the case of insulin. The student in the course in biochemistry would be expected to learn that insulin is a hormone secreted by the pancreas, that it is necessary, why it is necessary in the proper utilization of carbohydrate by the body, and that a lack of it results in the condition of diabetes; and he should learn what is known about its mechanism of action. What, in addition to this basic biochemical information, should the pharmacy student know about insulin? Should he not know, in addition, something about the various forms of insulin that are available for use, how they are prepared, their relative advantages and disadvantages, the stability, storage requirements, and dosage levels of the various available forms? Where, or in what courses, is he to get this additional essential information? We can all agree, I believe, that he should get it in one course or another and that he should get it after he has acquired the basic biochemical understanding of the nature and function of insulin in the body and not before, and that he should not be bored with needless repetition of the information in every other applied course in the curriculum. It is conceivable that he might receive a great deal of the pharmaceutical information about insulin in an expanded course in biochemistry that is slanted more particularly to the needs of pharmacy students. Or by proper correlation and integration he might get information concerning the preparation of the various forms, their stabilities and storage requirements in the course in pharmacog-

nosy, and their dosages and relative advantages and disadvantages in the course in pharmacology. Under such an arrangement the teacher of the course in the chemistry of organic medicinal products and the teacher of dispensing pharmacy would have little or nothing to say about insulin, nor should they if it has been properly and completely covered in the other courses. But the important thing is to be sure that the teacher of pharmacognosy or pharmacology be aware of what has already been covered about insulin in the previous courses in order to avoid needless duplication of that subject matter.

What is the answer? How are we to achieve the necessary correlation and integration that appears to be needed now and that will be needed more than ever in the future as more schools adopt required courses in biochemistry and as more schools adopt the modern approach to pharmacognosy? To return once more to the Pharmaceutical Survey committees which looked at the pharmaceutical curriculum, it is apparent that they treated their fields of interest individually and separately and that there was no effort made among the individual committees to discover points of common interest and impingement in the subject matter and course content of the various courses which they recommended; in other words, no attempt was made among the committees to achieve the correlation and integration of the various recommended courses that would lead to a well co-ordinated curriculum. Nor is it anticipated that such an attempt will be made in the forthcoming Pharmaceutical Survey monograph on the pharmaceutical curriculum.

I do not feel that it would be possible for any group of committees or for one or two individuals, for that matter, to do this job of correlation and integration for us and I feel that it would be a waste of time for them to try. The job must be done by ourselves and our colleagues on the staff of every school of pharmacy and it must be an individual job for each school. One of the most important principles of curriculum organization pointed out by the Pharmaceutical Survey was that, in the final analysis, the development and application of a curriculum in any school of pharmacy are primarily the responsibilities of the faculty. (9) The word "syllabus" may recall unpopular memories for those who remember the Pharmaceutical Syllabus and its demise which followed its fifth edition in 1945. Nevertheless a syllabus - not one for all schools but one for each school, compiled and edited by the entire staff - seems to be what is needed to achieve the desired co-ordination in the curriculum of each school.

We may ask ourselves what <u>is</u> biochemistry; what <u>is</u> the chemistry of organic medicinal products; what <u>is</u> pharmacognosy? And we might find answers and definitions that are suitable for our purpose here in this Seminar but they would not fit more than a few of the schools. No individual or group of individuals can specify what the pattern should be for every school. The faculty of each school, working in close co-operation, must decide for itself the answers, set up the scope, course content, and subject matter for each of its courses and construct its own syllabus accordingly. Thus, for example, if pharmacognosy is to be presented by the traditional approach in a given school and biochemistry is a required subject, the syllabus for that school will follow a particular pattern. On the other hand, if pharmacognosy is to be presented by the so-called modern approach, with more emphasis on the biochemical aspects and on the chemistry of natural products, then the syllabus to fit such a situation should be formulated very differently and very carefully as to scope, course content, and subject matter of the courses in pharmacognosy, biochemistry, and the chemistry of organic medicinal products. In this case biochemistry should precede the course in pharmacognosy and it must be recognized and agreed that in this case the chemistry of natural products is to be covered in the course in pharmacognosy and not in the course in the chemistry of organic medicinal products.

Although all of the courses in the professional years of the pharmaceutical curriculum may be regarded as applied courses, at the same time it is recognized that some of them are more fundamental than others. It should be kept in mind at all times that the more fundamental of these applied courses should be given in their proper sequence and there should be avoided the mistake of teaching fundamentals, whether they be chemistry, biochemistry, pharmacognosy, or pharmacology, under the guise of courses which are supposedly devoted to applications of the subject.

Finally, the correlation and integration of course content and subject matter among the courses must be made not only on paper in the form of a syllabus but it must be made <u>in fact</u>. This might be accomplished in an ideal way by arranging for two or more of the faculty to have joint and co-operative responsibility for a particular course, with each one assigned that part of the subject matter in which he is particularly interested or well qualified. Precedent for such a procedure is found commonly in courses that are given in other professional schools, such as medicine, and in graduate courses. In the absence of such an arrangement there must be close co-operation and personal conference among the teachers concerned, with each one informed on what is being presented in the other courses. Only in this way can the properly co-ordinated curriculum be actually achieved.

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THE PLACE FOR A GRADUATE PROGRAM IN PHARMACY

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About four years ago Dean Rogers told me that he was concerned because, although he had at his disposal funds to provide several fellowships for graduate study in the College of Pharmacy, there were no applicants for the fellowships. The only explanation I could offer was that probably some teachers or others had been remiss in not acquainting the students with all of the several functions of the profession. The responsibilities of pharmacy include all of the services involved in the preparation of medicines, from the collection or manufacture of the crude raw materials to the final compounding of physicians' prescriptions.

There are several separate classes of pharmaceutical functions, including at least the following:

1. Collection or manufacture of raw materials.
2. Production, by extraction, synthesis, or refining, of pharmaceutical chemicals and drug educts.
3. Collaboration in establishing the therapeutic worth of a product, including the selection of the most appropriate form for administration.
4. Identification and evaluation by assay of these raw materials, and control, by appropriate scientific techniques, of manufacturing operations.
5. Quality control during distribution, and enforcement of state and federal drug laws.
6. Promotion, including detailing to physicians and pharmacists, and distribution through the retail trade, including dispensing.
7. Education of pharmacists.

Of these, only retail distribution is seen by the public, hence they think this is all there is of pharmacy. This must be more than a lay impression for during the deliberations of the Pharmaceutical Survey members of the committee were quite insistent that the reports should recommend that colleges of pharmacy limit their admissions to a figure that would insure only adequate replacement among the registered pharmacists of that area. With so much emphasis placed upon preparation of students to practice retail pharmacy, it is not surprising that better-than-the-average students think of the senior year as the terminal year of their professional education.

Because of my own connection with a research institution, I have been questioned many times about the possibility of establishing a research program in a college. Some college administrators think that a research program would be a direct money-maker for them, while some, who must realize that industrial research requires the aid of development, production, promotion, and sales to break even, let alone make money, think that a research program would be something nice to have around the college. A few well-chosen pictures in the home may turn the eyes of the family to better things, and even a modest research program that is not merely a pretense is a good thing for any college, but there must be a fitness about the relation of research activities of the college to its academic program. It is axiomatic that emphasis on a graduate program in any school should be withheld until the program of undergraduate instruction and the mechanisms for providing such instruction are in good order.

It is necessary to think of two aspects of research in a college, the personal research of the faculty and the directed research of the students. It is easier to develop a graduate research program if there is, first of all, a substantial engagement in personal research by the faculty. There always can be faculty research without research students. It is only the most exceptional scientific department in a prominent university that can have a body of graduate students even equal in number to the departmental faculty, and in such departments only the better known men are sought after by graduate students as research advisers. Personal research can bridge the gap between the teacher's graduate-student days when he was carrying on directed research, and the time when he has attracted enough attention to be asked to become an adviser in a directed program. The failure of some young men in the educational field to live up to the promise they showed when they were on the operating end of a directed program could be due to the fact that as graduate students they were used only as pairs of readily available hands. There have been research students who were completely dominated by a selfish faculty adviser. Consequently, the young Ph.D. may need to acquire personal confidence. There is a responsibility resting upon the administrator to direct that younger person's energies in such fashion that he can acquire some confidence in himself as an adviser as well as a worker.

Each year our colleges of pharmacy add to their faculties young men of professorial rank who have just completed, under direction, creditable research. Often they are married and have little hostages to fortune dependent upon them. They come to a new community, they buy a house on a shoestring, and

set themselves the task of making it habitable and merchantable by the work of their own hands. Wearied by physical labor and also conscientiously trying to make up to the family some of the friendships that have been lost in moving, they are forced to let the resolves to continue as adventurers in the research field, made at the time of completion of the thesis, go glimmering. Even salaried research workers, who have only to put certain of their releasable accomplishments on paper, often become lost to scholarship through domesticity.

We are now in the midst of an argument over the extent to which an education in the liberal arts should precede professional education. Medicine, and quite generally dentistry and law, have made such an education mandatory. I think that in a few years it will be generally accepted by our colleges of pharmacy. The factors that determine the extent of preprofessional training are (a) the basic education necessary to comprehend professional instruction and (b) the basic education necessary to perform the duties of a citizen. We have a pharmacist of sorts in the U. S. Senate and others in the House of Representatives. One has just concluded a term as governor, and many others hold state, county, and municipal offices. A pharmacist, therefore, may be as responsible as any other citizen and because of his professional position should take pride in being above the mean in education.

If all professional occupation stayed at the same level one general pattern should serve for all professional education. The commonly accepted level for any profession, and for the degree of training as well, is that at which the significantly greatest number of professional workers find their occupation. In the practice of pharmacy an undetermined majority, probably better than 75 per cent, are engaged in the retail trade. The highest exemplification of this is found in retail dispensing and hospital pharmacy. At this same level will be found the skill required for the direct supervision of manufacturing operations and the form of professional relations known as detailing. The terminal courses in the undergraduate curriculum are believed to fit students to go directly into these occupations after, of course, any sort of internship required for occupational orientation.

Each of us will probably use a different yardstick to measure the capacity of a new B.S. in pharmacy. For my part, I have found that the graduate in pharmacy who has been trained by a good faculty and has taken advantage of his opportunities is almost as good a chemist, except for deficiencies in mathematics and physical chemistry, as the graduate of the chemistry curriculum, is probably a better chemist than the average liberal arts chemistry major, with the exceptions before noted, and has a better manipulative skill than either. Perhaps this speaker would not be so bold in his last assertion were it not for his experience in the employment of research assistants.

This competence is based upon fundamental training which has all been pointed toward one goal. When a college is sufficiently staffed and equipped the graduates may have had a bit more choice as to their mental equipment by the selection of certain optional course sequences during the latter part of the curriculum. No student can make use of options effectively without adequate advice, and even though he elects options other than that of retail pharmacy he has only completed an apprenticeship when he receives the bachelor's degree.

Why should a student elect to enter a graduate school, and when should a teacher encourage him in that desire? One reason upon which I think nearly all will agree is the need for well-trained teachers. Such teachers are needed for replacement and for expansion. In the past faculty replacements were largely recent graduates who could be persuaded to remain for the sake of position or security. It was little more than the promotion from the private to private first class, corporal, and sergeant, a question of time, good behavior and a modicum of intelligence. The late President James of Illinois told his faculty in 1918, when the Student Army Training Corps was being activated and registration was skyrocketing, that they might be called on to teach unfamiliar subjects. He said that he, an economist, once in an emergency had been forced to teach zoology. He went on to say that in such an emergency as we were then facing, he felt that we ought to be able to keep a day ahead of the class.

We have had a certain number of cram schools, but the movements instituted by the A.A.C.P. and the N.A.B.P. for the beneficiation of pharmaceutical education have made them a thing of the past. Last year's graduate can serve as a cram-school quizmaster with the aid of a suitable manual, but he cannot be very efficient as a teacher in keeping abreast of the rapid developments in pharmaceutical science. The graduate school is, without doubt, the best place from which to secure capable teachers. The proposed restriction of freshman class admissions to the number necessary to supply replacements for retail pharmacists lost by death, retirement, or disgust makes no provision for supplying either new teachers or replacements.

Many of us close to the profession have been disturbed over the lack of concern of many pharmaceutical industrialists about the affairs of organized pharmacy. Do we realize how many of the executives among them come in through other lines, such as finance, and how many of those who come in through the scientific departments come out of chemistry, engineering, and medicine and can therefore be out of tune with the traditions of pharmacy? Industry is not to blame for the presence of such persons in executive positions. Well-trained scientific and technical men are required, and pharmaceutical industry must take them where they find them if pharmaceutical education cannot take care of the demand. These persons serve the company in the long run as

well as those of equivalent training who have come up through pharmacy; they cannot, however, always see professional needs through pharmaceutical eyes.

I do not propose to stand here and say that a person with a pharmaceutical background can do this job better, for my whole experience in research management has shown how well-grounded scientists of the chemical persuasion can adapt themselves to new fields. After such adaptation, they often bring in novel and valuable ideas. Pharmaceutical industry is going to survive without a supply of scientific and technical managers from the colleges of pharmacy. Hasn't it been a bit dumb, though, to make so little motion towards pre-empting a good share of these opportunities, particularly when there are still numbers of pharmaceutical executives who would be happy to have more pharmaceutically-backgrounded personnel in their organizations?

The retail practice of pharmacy will go on if every graduate of a school of pharmacy is cast in the very same mold, each a replica of every other. What a sameness of pharmaceutical outlets there will be. They will resemble nothing else so much as a row of vending machines. Even now much of the clutter of merchandise that clogs the aisles and counters of the average drugstore is there because in the pharmacist's willful acceptance of long hours, when even the hamburger stand is closed, he provides a never failing outlet for the distribution of all manner of notions. Pharmacy in its derivations is as broad as medicine, so we can only be giving lip service to professional claims when we make no effort to advance beyond a broad retail level. The effect of that lip service is evident when we encounter opposition to providing more professional openings for pharmacists with the armed forces.

It is my considered opinion that graduate study in pharmacy is a good thing for many of its members and certainly a good thing for the profession. I don't think pharmacy is entitled to professional status without it. But what of the college? Is it essential that a college have a graduate program? What can the college gain from graduate instruction, including research?

Webster has two very comprehensive definitions for the word "college": (a) "A body of persons having common interests or corporate functions" and (b) "A society of scholars incorporated for study or instruction, especially in the higher branches of knowledge." Even the definitions for "school" in general imply that there is no end to learning. Therefore, whether by school or college, the educational purpose should be continuous. The late President Garfield once described a college as "Mark Hopkins on one end of a log and a student on the other." My father told me once of falling into conversation with a young man who said that he had "been doing a good bit of 'voluminous' reading lately." It turned out that he had given up dime novels for bound volumes of the better forms of literature. Here was a studied effort to improve without adequate direction. The state "teachers reading circles" were an endeavor to guide the mental processes of learning beyond the formal studies of the undergraduate classroom. A person of unusual accomplishments can go far by private study, but for the average scholar guidance is needed.

The operations of a college of pharmacy usually call for the services of a certain number of younger persons as laboratory or quiz instructors. Efficient teaching calls for more than that "one day ahead of the class" of which I have spoken. Since these younger and lower salaried members of the faculty probably have not gone far beyond the undergraduate level by this time, their performance will be improved by a study program, which will be more productive of benefit if organized under the guidance of some experienced faculty member. The continuation of advanced study makes for a better teaching effort all round. It lessens the possibility of a student, chided for failure to use a notebook during a lecture, replying, "But I have my father's notes, Sir!"

To continue advanced study does not necessarily call for organization of a graduate faculty, but if in the university of which the school is a part there is a graduate faculty, the liklihood of receiving graduate credit will be an encouragement to the student. The first organized program should have only the educational needs of the school in mind, rather than being set up as a promotional drive for a larger student body.

The foremost reason for organizing a program of advanced study is its value in providing more inspired, informed, wide-awake instruction. This might be carried on for years at the master's level or even without a terminal degree, but I believe that the award of recognition is desirable. The worth of continuation of study to the highest level, the doctorate, is more debatable. It is hardly as necessary for what we might call "in-service" training of a faculty, because by that time the student should be better able to go on leave to a superior graduate school where the doctorate may be more profitably taken. A far-sighted administrator, finding a young teacher who showed desirable promise, would do well to finance that teacher in his final attainment of the doctorate in order to reap the intangible benefits of having such a person as a permanent member of his senior staff.

If an institution plans to maintain a graduate department upon a high level, for the purpose of awarding the doctor's degree and making a name for itself by the quality of its research, it must be bound to maintain a superior faculty. No small part of the maintainence of a graduate faculty of high attainment is the continued attraction of superior students. Students are attracted by faculty reputations as well as by facilities for research. The faculty members

must be given every opportunity to become and remain known. Such persons must not be burdened with class and paper work to the limit of endurance. Neither can these responsibilities be thrust upon other wheel-horses, except those few who have dedicated themselves to a monasticity of teaching, without causing jealousies that may eventually wreck the whole faculty. That these persons may have every opportunity to become and remain known they must publish original research at frequent intervals and they must be seen and heard, if possible, at frequent gatherings of scholars in the field. The research requires time, and funds for facilities and assistance; and attendance at meetings not only requires travel allowances but also demands provision for carrying the teaching load of those who are absent. None of these things can be provided without the sympathetic understanding of the school administration and those who must provide for the institution the necessary financial backing beyond the student fees.

Sympathy for advanced study and research is somewhat more easily obtained today than a half century ago, yet even today the money must be found by people who are practical in their viewpoint. Robert Kennedy Duncan, founder of the Mellon Institute system of industrial fellowship research, wrote of American industrialists in 1907, "Manufacturers of the last generation were, generally speaking, men endowed with great natural abilities but of small education -- men who, starting as factory 'hands', worked themselves up through the grades of foreman and superintendent to managerships and presidencies. To such men, science and the scientific method meant literally nothing; it was outside of their ken, and they had all of the impatience and disdain of the 'practical man' for the 'theoretical fellow.'" I am quite sure what Dr. Duncan had in mind. Most of us have had our courses, particularly our laboratory instruction, criticized for lack of practicality. I encountered this in my very first course, prerequisite quantitative analysis for students in agriculture, when they, and some of their class advisers, objected because they were not put immediately on the analysis of fertilizers, feeding stuffs, and soils.

Wherever we are to have a real graduate faculty there must be an inspired leader, a man of vision, of understanding, and possessed of powers of persuasion. He must be strong enough to fight off the practical man who only condones scholarship. He must be kindly, firm, and diplomatic in his leadership, for not all students and teachers are born to be scholars or research directors. He must exercise his judgment in the leading of his faculty as well as his students, for a research faculty ought to train research leaders as well as research workers. A research leader of reputation, who has an excess of ambition, may often times corral for himself all or many of the likely looking students entering for advanced study, possibly only for the sake of padding his own publications list. This practice does not offer much opportunity of developing research leaders among the younger faculty members and has been known to drive some away for lack of opportunity.

I think that if I were research administrator of a college faculty I would endeavor to assign research students at various levels so as to give every faculty member who so desired a chance to prove his ability. When I have proposed this privately I have always met the same objection, "Suppose all of the students want to work in physical (or organic) chemistry?" These objectors do not share my thinking that a thesis is an administrative means of developing and measuring research ability. I would provide the area training by an ample number and distribution of good seminar courses.

If you are curious, take the catalogue of some large chemistry department, and check the senior faculty list against Chemical Abstracts. If you go back far enough in the list of each person's publications, I predict that you will find a preponderance of theses in organic chemistry. Yet these are probably strong departments from the chairman to the newest associates. In my first year as a full-time faculty member eleven of the eighteen comprising the senior faculty had their terminal degrees in organic chemistry, yet it was considered a well-ordered and well-rounded faculty. The choice of a major field for graduate study was, without doubt, influenced by the prevalent conception of the time that must be spent in completion of a thesis. In my own time as a graduate student, it was the popular belief that when a research student in organic chemistry had made fifty new compounds his degree was assured.

I must tell you of an amusing, and pathetic, interview I had a few years ago with a young Ph.D. from a prominent eastern school who was hoping to find a position with us and proclaimed himself to be an organic chemist. I immediately began to run over with him various openings for which we could use organic chemists, mentioning wool technology, cotton finishing, writing paper, and a project in the treatment of industrial wastes. He looked more and more bewildered and finally as though he was listening to an idiot. Then, very kindly and considerately, he said that I must have misunderstood him, because he was hoping to find a position as an organic chemist. He could not understand why we should want organic chemists for these industrial problems because, as he explained, organic chemists devote their energies to chemical syntheses. When I am asked to advise a graduate student as to the choice of a major field, I always suggest that it be in the field and under the adviser where he will find the most pleasure, because the subject of his thesis will probably have little to do with his ultimate occupation.

Graduate study and research are not going to pay off the mortgage on the pharmacy building. One of

my very good friends had the naive idea that he might find a pharmaceutical house or two that would establish fellowships in his school, in which case the profits from the inventions would pay off the deficit on the school's operations. Many people have difficulty in distinguishing between the management of research for scholastic purposes and research for profit. As far as the research itself is concerned, about the only difference is that research for profit is carried on by already trained research workers, whereas research for scholastic purposes may be one of the phases for training research workers. It is always embarrassing to try to distinguish between pure and applied research because the pure research of today is so often the delineation of the basic principles of the applied research of tomorrow.

My friend then said that it was too bad that they did not have an eight-million dollar plant such as ours because in that way they could accomplish such wonderful things in research. The plant to which he referred was only a stage in evolution. It grew out of a five-hundred dollar fellowship awarded to Fred Farragher at the University of Kansas in January 1907 to study the chemistry of laundry supplies. Out of that grant Fred paid his tuition, purchased supplies, and had the balance for living expenses. The second fellowship, incidentally, was established by Parke, Davis and Company, in the same amount, the same year, for an investigation of diastase in green plants, especially alfalfa. Ralph C. Shuey was the incumbent of the fellowship, and later was connected with the development of "Bakelite." Thus, the Industrial Fellowship system began. Out of those experiences came the development of Mellon Institute in Pittsburgh, first a frame building, then a modest building of brick and stone, and finally our present home, of which we are justly proud.

For me to present uncontrovertible justification for graduate study in schools of pharmacy would be like trying to give convincing proof of the infallibility of some beliefs in Christianity. I can't tell you exactly why, but I believe; just as I believe in graduate study and research as a part of pharmaceutical education. Suppose we let it rest there.

THE NEED FOR GRADUATE PROGRAMS IN PHARMACEUTICAL ANALYTICAL CHEMISTRY

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I am in somewhat the same situation as the girl with a master's degree in education who said that she never could understand modern theories of education, but that she knew the words. I am not an analytical chemist, but my work during the past several years has brought me into contact with many analytical and control chemists in the pharmaceutical industry and with teachers of analytical pharmaceutical chemistry in colleges of pharmacy. Through these contacts, I have learned the "words," and have become familiar with some of the pharmaceutical problems requiring analytical treatment. Moreover, I have developed a tremendous respect for the role of analytical chemistry in pharmaceutical research, development, and control.

Probably I was asked to speak on the need for graduate programs in analytical pharmaceutical chemistry because of something I said here last October, during the seventy-fifth anniversary celebration of the College of Pharmacy of the University of Michigan, when I had the temerity to predict the direction in which graduate research in colleges of pharmacy would develop during the next twenty-five years. At that time, I said that research programs within the framework of colleges of pharmacy now include plant chemistry, medicinal chemistry, pharmacology, and pharmacognosy in various stages of development, and predicted that research in these areas would continue and would expand in the future. I expressed the opinion that two other opportunities exist for expansion of pharmaceutical research in the fields of pharmaceutical analytical chemistry and in pharmacy. Under research in pharmacy, I stressed the need for training that would fit students for positions in product development.

Concerning analytical chemistry, I said: "Analytical chemistry, applied to the analysis of foods and drugs, has long been a part of graduate and undergraduate pharmacy curriculums. Like other supporting subjects, analytical chemistry has changed tremendously during the past twenty years, and particularly during the last decade. Conventional methods of assay have been supplemented, and in some cases supplanted, by new methods. Because of the high cost of many of the newer drugs and the minute doses used, micro and semimicro methods are frequently indicated. Instrumentation methods, broad in scope, are now used routinely as analytical tools. Spectrophotometers in the ultraviolet and the infrared ranges are becoming commonplace. With the new type drugs now being used, analytical chemistry offers a natural field of research in pharmaceutical chemistry. Several pharmaceutical chemists are now engaged in research in analytical chemistry, but this specialization has not been highly developed as a graduate specialty in any college of pharmacy. It offers great opportunities, and within the next twenty-five years a few colleges of pharmacy will realize the possibilities in this area and will develop strong research programs in analytical chemistry applied specifically to pharmaceutical products. In order to accomplish this, it may be necessary to obtain research directors without pharmaceutical background, but with modern training in analytical chemistry and an interest in its applications to pharmaceutical problems. This would be no different from the first academic approach to research work in medicinal chemistry."

It appears that I am now expected to elaborate upon the statement just quoted, and possibly defend its inherent implications. For the immediate purpose of this discussion, it may be well to limit the question of the need for graduate programs in pharmaceutical analytical chemistry to those leading to Ph.D. degrees. I have discussed the subject from this viewpoint with several analytical chemists holding responsible positions in analytical and control laboratories in the pharmaceutical and allied industries. Some of the reactions elicited were favorable to the idea, and opinions were expressed that opportunities would exist in the industry if well-trained Ph.D.'s in pharmaceutical analytical chemistry were available.

The consensus of those who could see no need for graduate programs in pharmaceutical analytical chemistry seemed to be that the training in this specialty for positions in the pharmaceutical industry should be left to chemistry departments in universities, and that if graduate training in this subject were developed in colleges of pharmacy, it might be so highly attenuated that the students would be trained inadequately for fundamental research in analytical chemistry.

These opinions indicate an amazing lack of knowledge concerning the present status of graduate study in colleges of pharmacy, and the potential for expansion

that exists. If we may assume that the existence of colleges of pharmacy is justified, that these colleges function on the same level as other institutions of higher learning, and that the development of any graduate program under their auspices is justified, we then have some basis for believing that programs leading to the Doctor of Philosophy degree in pharmaceutical analytical chemistry come within the province of these colleges. If it is correct to assume that graduate study in analytical chemistry should be left entirely to chemistry department faculties and facilities, it would also be proper to make comparable assumptions about medicinal chemistry and pharmacology. No one with a knowledge of pharmaceutical education would either make or accept such assumptions.

When we speak of graduate work in any one of the several ramifications of basic and applied sciences that collectively make up what we call pharmacy, we definitely do not think of it as being composed of diluted courses and inferior research problems whereby students may obtain advanced degrees by an easy route. It is unfortunate that such opinions appear to exist, but they can be accounted for by the general lack of knowledge of the rapid strides that have been made during recent years in the development of graduate study within the framework of colleges of pharmacy.

As far as analytical chemistry is concerned, most of us would agree with I. M. Kolthoff who is reported (1) to have said that academic training of Ph.D.'s should be in the basic aspects of chemistry with special emphasis on the scientific fundamentals of analytical chemistry. We might go a bit further and say that a research problem for a graduate student should be in a specialized field that eventually could be applied to the solution of pharmaceutical problems.

One analytical chemist, in an administrative position in the pharmaceutical industry, believes that a pharmaceutical background would be advantageous for some analytical chemists in this industry, but that his graduate work would be more valuable if directed by a chemistry department faculty member. As an alternative, he suggested that cooperative programs could be worked out advantageously between pharmacy and chemistry faculties. This idea might have merit, but it is extremely doubtful that it would work in actual practice, and it certainly would not enhance the reputation of a college of pharmacy in the area of graduate study.

We are all conscious that some colleges of pharmacy now have graduate research programs in pharmaceutical analytical chemistry. A check of the papers published during the past eighteen months in the Scientific Edition of the Journal of the American Pharmaceutical Association, reveals that 14 per cent of all papers published during 1951 were strictly in this field. For the first six months of 1952, papers in this area account for 28 per cent of the total. Exactly 50 per cent of all the papers in the analytical classification for the eighteen-month period represented research contributions from colleges of pharmacy. The others came mainly from pharmaceutical industry laboratories. This spot check did not include analytical research co-ordinated with other problems. It it had, the percentage figures would have been much higher.

The figures covering such a short period of time are not sufficiently significant to indicate an upsurge of interest in analytical pharmaceutical research, but they do show a trend in that direction, even if most of the papers reported the results of applied instead of basic research. None of these papers was based on a Ph.D. dissertation.

What reasons are there to believe that if research programs in pharmaceutical analytical chemistry were to be highly developed as a separate specialty by colleges of pharmacy, there would be opportunities for their graduates? Admittedly, we have no precedent here, as we have in medicinal chemistry and pharmacology, upon which to base an answer. There are, however, many reasons to believe that opportunities do exist in the pharmaceutical industry. It has been estimated (2) that this industry produced one billion dollars worth of products in 1951. According to the 1946-1949 Pharmaceutical Survey (3), it spent fifty million dollars on research in 1947.

A summary of the results of a survey, conducted in 1951 by the National Scientific Register (4) indicates that there are approximately one hundred thousand chemists employed in the United States. This estimate was based upon data obtained from questionnaires returned by approximately 52,000 chemists. Of this number 2,952, or 8.9 per cent, are employed in the pharmaceutical industry. Research and development form the principal activity of 45 per cent of all chemists, according to the survey. These figures, as they relate to the pharmaceutical industry, are impressive, and seem to indicate that there would be opportunities here for Ph.D.'s in pharmaceutical analytical chemistry if they were available.

It is self-evident that analytical chemistry is indispensable to an industry composed of more than a thousand manufacturers, and producing some twenty-five thousand items (3), all of which require quality control from raw materials to finished products. It has often been said (5) that drug products are hedged about by more governmental regulations than any other type of commodity on the market. The responsibility of a drug manufacturer is indeed great and expensive, but thoroughly justified since the health of the nation is concerned with the production of safe drugs.

Not all controls for accomplishing the production of safe drugs involve the application of analytical chemical methods, but these methods are definitely basic in character, and must precede, come at intermediate points throughout, and occur at the end of production. The work of the analytical chemist begins

with the determination of the strength, quality, purity, and identity of the basic ingredients, and ends with an examination of the final product designed to show that it complies with previously established standards.

These established standards may be those of the United States Pharmacopeia or the National Formulary, but very frequently they are specifications developed to suit a particular need for an unofficial drug. As a matter of fact, most official standards for drugs and dosage forms are based upon assay methods and other specifications devised by analytical chemists in pharmaceutical manufacturing laboratories where the products were first developed. Before such standards become official, however, it is frequently necessary to subject them to collaborative study in order to ascertain whether or not comparable results can be obtained by analysts with varied skills and different types of educational background and experience. Thus, the application of official methods of testing and assaying drugs in most cases does not require the services of a highly qualified analytical research chemist, but may be entrusted to an analyst.

The pharmaceutical industry, however, requires the services of both analytical chemists and analysts. Elving (6) defines an analyst as one who puts into practice the work of the analytical chemist, the person concerned chiefly with the exercise of analytical chemistry. He goes on to say that "in many situations the analytical chemist and the analyst are identical; each must always be something of the other. Both the analytical research chemist and his co-worker, the practicing analyst, have the same goal -- knowledge of the composition and constitution of matter within the limits specified."

For many years colleges of pharmacy have been training men and women to serve as analysts in pharmaceutical manufacturing laboratories, but most of them have been graduates of the four-year course, or have completed not more than one year of graduate study. This type of training is not adequate now, and will not be in the future, for research pharmaceutical analytical chemists.

What, then, are the distinctions between an analyst and an analytical chemist? According to Elving (6), "Analytical chemists are those principally concerned with the design, planning, and systematizing of the field of analytical chemistry. . . .they must have, if not a working knowledge, at least an awareness of the applicability and limitations of methods, techniques, facts, and instruments. . . .In solving analytical problems, they must bring to bear on the situation many streams of knowledge; in devising analytical techniques, they must be alert to the possible development of any device or means of measuring chemical reactivity or physical behavior into a means of determining composition.

"In approaching an analytical problem, the analytical chemist must have the background and ability to evaluate possible analytical methods from the viewpoints of interference, range of applicability, necessary modifications, and preliminary treatment, as well as the valid interpretation of the experimental measurements obtained. He must know not only how to use the multitudinous analytical techniques at his disposal, but, perhaps more importantly, when to use them."

Wayne W. Hilty (7), presumedly writing from a pharmaceutical viewpoint, says, "The analytical chemist is frequently asked to predict what will take place when certain compounds are mixed or combined. Not infrequently, he is assigned the task of determining what actually has happened to a product that has deteriorated or changed in some chemical or physical manner. . . . He must be competent in applying the identification and assay techniques of the organic chemist, the biochemist, and those of all other branches of chemistry; and certainly not the least important among the requirements for a good analyst is his ability to compose a complete and intelligent report of his investigations."

Pharmaceutical analytical chemists of the future, meeting these and other requirements, may be developed either from analysts by on-the-job training, experience, and additional study, or by training at the Ph.D. level either in analytical chemistry or in pharmaceutical analytical chemistry. The last seems to offer the most attractive possibilities. The young Ph.D. in pharmaceutical analytical chemistry would have an educational background and foundation not possessed by one whose basic training was in another field. He would go to his first position with an already acquired knowledge of the nature of the materials from which drugs are derived, and a familiarity with drugs and the composition of their dosage forms. He would possess a knowledge of, or at least a speaking acquaintance with, the biological sciences that would give him a greater confidence in approaching the many problems requiring teamwork with other scientific personnel.

In addition it is assumed that he would have acquired, during his years of graduate study, an academic background essentially equivalent to that required by a university chemistry department for a comparable degree. A person with this background would still require orientation and indoctrination in his first job, but the time required for this would be materially shortened and most of the effort spent for on-the-job training could be saved.

Concerning the need for analytical chemists, Edgar B. Carter (5) says ". . . better-trained chemists are essential, and in order to attract the better-trained men, a satisfactory future must be provided for them. Either the control laboratory must be a stepping-stone to a position of greater responsibility in the plant, or the administrative branch of the business, or the ability of a productive and dependable control chemist has to be recognized and recompensed properly."

The possibility of analytical chemistry serving as a stepping-stone to an administrative position is

intriguing. Undoubtedly the ability and acquired knowledge necessary to analyze materials can be adapted to the analysis of situations and problems faced by management. It should also be adaptable to product development in the pharmaceutical industry.

The wide range of pharmaceutical interest in analysis is indicated by reference to the three "Annual Reviews of Analytical Chemistry" having pharmaceutical applications which have been compiled by Wayne W. Hilty and Max M. Marsh (8, 9, 10), covering a three-year period. It is significant that during the years 1949, 1950, and 1951, more than five hundred publications are cited as having application to pharmaceutical problems. The methods recorded in these literature citations cover essentially all types of analytical procedures, both of the older and more conventional types, and modern methods involving the use of instruments which have been developed during recent years to a stage where they do not require the constant service of an equipment expert.

A perusal of the "Annual Reviews of Analytical Chemistry" relating to fundamental analysis, the first of which was published in Analytical Chemistry in 1949, reveals that there are many unsolved fundamental problems in the classifications covered in the Hilty reports (8, 9, 10) on applications. Reading these reports serves to dispel any notion that analytical chemistry is static, that its practice in the pharmaceutical industry is entirely of a routine nature, or that the development of instrumentation methods offers solutions to all problems. Instead, these annual reports indicate that analytical chemistry is still a dynamic branch of chemistry applicable to nearly all pharmaceutical manufacturing procedures. It also emphasizes that, while much routine analytical work is required, there are still opportunities for both applied and basic research, and that instrumentation methods provide useful tools that can be used after other fundamental data have been obtained by conventional methods.

For academic pharmaceutical analytical research, chromatography of all types, extraction methods of separation, instrumentation methods, methods for the characterization of organic compounds, particularly those of natural origin, and many other specialized branches of analytical chemistry with possible pharmaceutical applications appear to offer great opportunities.

College of pharmacy faculties, before attempting to develop highly specialized research programs in pharmaceutical analytical chemistry, would doubtless want to give the matter considerable study. They would probably want to have some assurance that an actual need for such a program exists. There is no way, as far as I know, of obtaining a definite answer to that question. It would be useful for the training of future teachers of pharmaceutical analytical chemistry and for positions in government laboratories. What the opportunities for Ph.D.'s in analytical pharmaceutical chemistry in the industry would be, is something to be determined. The scope of activities of the firms making up the entire pharmaceutical industry in this country varies considerably from one company to another. Some of the larger manufacturers can afford the luxury of Ph.D.'s who are specialists in spectrophotometry, polarography, and chromatography, to mention a few, but others can afford only a limited number of analytical chemists for their staffs who are expected to be versatile, capable, and familiar enough with the several specialties to apply them where indicated.

When I listened to the excellent presentation of Dr. Tishler on Wednesday afternoon concerning industry's requirements for pharmaceutical research personnel, I was deeply impressed. His viewpoint may, however, represent that of only one company with wide and highly diversified interests.

It should be the aim of colleges of pharmacy in developing and expanding research programs at the graduate level leading to Ph.D. degrees to determine the need, as far as possible, of all segments of the pharmaceutical industry. As a start toward accomplishing this aim, would it not be advisable to consider the possibility of arranging for a series of seminars devoted almost exclusively to industry's requirements for pharmaceutical research personnel in all branches of chemistry, and also in pharmacology, pharmacognosy, and pharmacy. Industry's participants in the program could be drawn from large, medium-sized, and small pharmaceutical manufacturing companies in order to obtain a fair cross section of opinion.

The drug manufacturers' associations assess dues of member firms upon the annual volume of business in terms of sales. One such association divides pharmaceutical and biological houses for this purpose into fourteen classes. Class A includes those doing an annual business of more than seventy million dollars per year, Class G those whose annual business is between ten and twenty million dollars per year, and Class N those with annual sales of less than five hundred thousand dollars. It seems reasonable to expect that the requirements for pharmaceutical research personnel of manufacturers in Class A would be quite different from those in Class G, and the needs of neither would be comparable to those in Class N. By choosing speakers, for example, on industry's requirements for pharmaceutical research personnel in analytical chemistry, from large, intermediate, and small manufacturers, a cross section of opinion on the needs of the entire industry could be obtained. The same device could be used for all other pharmaceutical fields of research. After having obtained the information that might come from such a seminar, colleges of pharmacy could more intelligently approach the question of their capabilities of developing graduate work to fill the needs of the entire pharmaceutical industry.

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A GRADUATE PROGRAM IN ANALYTICAL PHARMACEUTICAL CHEMISTRY

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I have been asked to outline and discuss the graduate program in analytical pharmaceutical chemistry which we here at the University of Michigan College of Pharmacy are in the process of developing. Perhaps the first question that comes to mind is, "Why should such a program be undertaken?" Dr. Powers has just discussed the need for such programs in terms of the job possibilities for graduates of the program, and I would like to add to this discussion some comments of my own. But before I do that, let me state rather briefly the basic reasons for the establishment of such a program here at the University of Michigan. It was felt that in order to attract desirable graduate students, a diversified research program should be available. Michigan has had a well-established program in the synthetic phases of pharmaceutical chemistry for a number of years under the able direction of Dr. F. F. Blicke. My principal interest is in the application of the newer methods and techniques of analytical chemistry, including, of course, instrumental analysis, chromatography, titrations in nonaqueous media, and others, to problems of pharmaceutical analysis. We are fortunately situated here, having a very fine working relationship with a university chemistry department which has long been recognized as one of the leaders in the analytical field. With these factors in mind and recognizing that there are widespread opportunities for constructive research in this field, we began about six years ago to develop a graduate program which would interest and attract primarily graduates of colleges of pharmacy who were interested in the analytical phases of pharmaceutical chemistry. At the present time students showing such interest are perhaps not as numerous as those wishing to enter the fields of synthetic pharmaceutical chemistry or pharmacology, for example; nevertheless, we have noted that among the graduates of those schools which are offering undergraduate instruction in pharmaceutical analysis along modern lines, there are almost always at least a few individuals who have developed such interest in this area of instruction that they wish to pursue it on the graduate level. It is perhaps fortunate that those desiring to specialize in this area are not too numerous because the possibilities of placement after graduation are admittedly somewhat fewer than those in certain other areas at the present time. I expect that as graduates of this program prove their worth in industry, governmental positions, and in teaching, placement possibilities will become more numerous than they are at present. Certainly our first Ph.D. candidate in this area, who is engaged this summer in completing his thesis, had no trouble in finding a suitable opening within the pharmaceutical industry.

There is a tendency I think among some to feel that the only opportunities in industry for men specializing in this area lie in the control departments. Adequate control of raw materials and of intermediates and finished products is a very important phase of the pharmaceutical industry. One of the principal reasons for the establishment of the United States Pharmacopeia was to furnish control standards for medicinal products. The immediate incentive for the foundation of the American Pharmaceutical Association was the bad condition still existing in the drug market in spite of the fact that the USP had been in existence for more than thirty years at the time. Lack of legal status for the USP minimized its effectiveness, and one of the objects of the APhA as stated in its first constitution was, "To improve and regulate the drug market, by preventing the importation of inferior, adulterated, or deteriorated drugs, and by detecting and exposing home adulteration." The passage of the Food and Drug Act of 1906 gave legal status to the procedures of the USP and NF and control departments began to be aware of the legal implications of their work. In 1938 the Food, Drug, and Cosmetic Act was passed. This immediately intensified the legalistic work of these departments and at the same time emphasized the need for more precise methods of assay. It also caused many of the smaller companies to establish or to enlarge and re-evaluate already existing departments or to arrange in other ways for adequate control procedures for their products.

Increased emphasis on control processes in general has increased the need for men with a satisfactory pharmaceutical education who at the same time have had good fundamental training in analytical chemistry to perform the routine work of the control departments. With the scope of the undergraduate pharmacy curriculum being constantly enlarged, it is becoming increasingly difficult to prepare men for such positions within the time limits for the bachelor's degree. Some further work, possibly culminating in a master's degree, may be necessary for adequate preparation for these positions. On the other hand, such positions do not offer the financial remuneration or the intellectual challenge to attract men who have completed doctoral degrees

unless they can look forward, after a reasonable period of experience, to responsible administrative or research positions within control departments. It is these latter paths that some of the men engaged in this program may follow. Certainly, with the rapid changes and advancements which are taking place in the analytical field and with new and complex medicinal agents constantly being developed, control directors of the future will need as much fundamental knowledge as it is possible for them to attain.

Research positions of an analytical nature are not at all uncommon in the pharmaceutical industry. Many of the problems investigated in product development departments require considerable analytical data for their solutions. Frequently, in order to obtain this data it is necessary to develop new determinative procedures or to make major modifications in existing procedures. Some companies maintain analytical research groups within their product development departments for this purpose and others rely on individuals within the control department. In either case the job is essentially applied analytical research and, I feel, represents a natural opportunity for graduates of our program. Such work is necessarily closely co-ordinated with product development, production, synthetic research, and control and consequently requires men with a working knowledge of these other departments.

Although I have been commenting primarily upon industrial opportunities within this field, there are similar situations in governmental work and there are also educational opportunities for those who wish to enter the teaching field. I certainly do not believe that every college of pharmacy needs to offer a graduate program of this type, but I do believe that every college of pharmacy should offer undergraduate work in pharmaceutical analysis of sufficient scope to provide all pharmacy college graduates with a realization of the importance of the control of the quality of medicinals to the practice of their profession. Furthermore, I believe that undergraduate courses in drug assaying offer an excellent opportunity to inculcate the principles of reasoning and logical analytical thinking as well as to offer, in the laboratory, increased opportunity for practice in precise weighing and measuring. I therefore think that at least three or four credit hours of drug assaying in addition to elementary quantitative analysis should be a required part of the undergraduate curriculum in pharmacy.

In addition to the primary purpose of this program, namely that of preparing men for such positions as those discussed above, the program can also function as a service program in several different ways. Since data obtained by means of analytical processes play a major role in the solving of many product development problems, students who are primarily interested in the pharmaceutical phases of product development and who are specializing in a graduate program in that area, would undoubtedly profit by some course work in analytical pharmaceutical chemistry. Some of the courses being offered in pharmaceutical analysis will help to provide them with a working knowledge of the field and enable them to work in close cooperation with the analytical specialists. Conversely, we expect that many of our students will have occasion to take some courses within the pharmaceutical development area. In this way each of these graduate programs supplements the other.

If the products prepared in the manufacturing pharmacy courses are to be utilized, they must of course be subjected to adequate control procedures. We are furnishing this service on a small scale at present and expect to expand it as our manufacturing pharmacy courses are expanded. A manufacturing-control relationship patterned closely after that used in industry should not only furnish the necessary control service but should provide excellent training for students in both areas. It is hoped that in the future it will be possible to establish within this program a position with the rank of teaching fellow in which the graduate student will do routine control work on the manufactured products as his half-time paid job and will devote the other half of his time to graduate work. Such a position would be held by any one student for one year only and preferably during his second year of graduate study.

Having discussed the objectives of our graduate program in analytical pharmaceutical chemistry, let us now consider the prerequisite training which is desirable and which may be reasonably expected of a student wishing to enter the program. The program is designed for graduates of accredited colleges of pharmacy. A nonpharmacy graduate would probably not find it feasible to spend the time required to make up deficiencies in pharmacy courses and courses in the biological sciences which would be required.

The broad scientific background and the feeling of responsibility for the public health as well as the knowledge of purely pharmaceutical processes and techniques which the undergraduate curriculum in pharmacy should provide, give the graduate in pharmacy a unique educational experience which, when supplemented by proper graduate work, should make him highly valuable in such positions as have been pointed out previously. The graduate program should be designed to capitalize the advantages of the pharmacy curriculum but at the same time should enable the student to acquire sufficient knowledge and training in the analytical field so that he will compare favorably with analytical chemistry graduates.

We would like to be able to assume that a pharmacy graduate entering this program will have satisfactorily completed standard courses in organic chemistry, biochemistry, quantitative analysis with some additional experience in pharmaceutical analysis, mathematics, physics, elementary physical chemistry, and a modern language, in addition to the strictly pharmacy and pharmaceutical chemistry

courses. It should not be too difficult for a pharmacy student looking forward to graduate work to meet these requirements. If deficiencies exist, they will most probably be in the areas of mathematics, physics, and physical chemistry. It is unfortunate, but true, that many pharmacy graduates who are likely candidates for graduate work have had insufficient opportunity to prepare themselves adequately in these areas during their undergraduate careers. If they then wish to obtain the maximum benefits from graduate instruction, they must be prepared to spend some extra time during their graduate programs in noncredit courses.

I would now like to direct our attention to the types of courses which constitute the formal academic part of this program. First, let me emphasize that I believe that the formal course-work part of each individual graduate student's program should be selected after careful consultation with the student and should be designed to fit his individual needs. Furthermore, this selection must be subject to revision as the student progresses in his research problem, therefore no rigidly prescribed curriculum of graduate courses will be presented. Instead, I would like to indicate a number of courses which are available here and from which a suitable selection can usually be made.

The course work in the graduate program must in my opinion serve two major purposes. It must give the student a sufficiently broad educational background so that he at least has a starting point from which to cope with any problem which is likely to arise in his later career. At the same time the work must be sufficiently correlated to achieve a considerable degree of specialization so that the individual will be useful upon graduation. Second, the course work should provide the tools necessary for tackling the research problem selected by the student or assigned to him. Incidentally, this implies that the major part of the course work should be completed early in the student's graduate career so that he can utilize the knowledge gained therefrom in his research work.

The selection of courses will be considerably influenced by the aspirations of the student. If he plans to terminate his graduate study with a Master of Science degree, he will necessarily pursue a different sequence of courses than would be chosen if he were planning to complete the doctoral requirements. We have not required a formal thesis for the master's degree. The minimum requirement, as far as the Graduate School is concerned, is twenty-four credit hours of graduate course work. Individual departments may establish their own requirements beyond this. At present, terminal master's candidates in this area are expected to have completed twenty-eight to thirty credit hours in a program approved by their graduate adviser, with approximately six credit hours of the total having been devoted to investigative work of a research character. An informal written report of this work is required. Since many of the courses are laboratory courses, the minimum time required is one academic year and one summer session of full-time graduate study. Obviously, these students are not qualified for responsible research positions. They are competent for control work under supervision and after having acquired further experience may be elevated to more responsible positions. Candidates in the doctoral program acquire a master's degree more or less as a formality after having completed course requirements.

Course work requirements for applicants for the doctorate are not rigidly prescribed; a program of courses is selected by the student and his adviser, and the completed program must be approved by the doctoral committee before admission to candidacy for the degree. The total credit hours will usually fall between thirty-four and forty, exclusive of languages and research. Reading knowledge of two modern languages, usually German and French, is required, as is a satisfactory report on preliminary and final examinations.

Certain courses almost always will be included in the doctoral program. Advanced Quantitative Analysis, Quantitative Microanalysis, and the Physicochemical Methods in Quantitative Analysis, as well as two courses in physical chemistry laboratory fall in this group. A physics course in electrical measurements is taken as a prerequisite for these. We offer a second semester of drug assaying as an elective course in our senior year. This can be taken for graduate credit by those who have not taken it previously and can be modified to some extent for graduates of other colleges of pharmacy in order to avoid duplication of and to complement their previous undergraduate work in this field. An advanced course in pharmaceutical analysis, in which the more complex procedures of the USP and NF and analyses taken from the recent literature are studied, is required of all students, as is a course in qualitative organic analysis.

In addition to these, a general course in advanced organic chemistry and a specialized course such as Reaction Mechanisms, Stereochemistry, Nitrogen Compounds, or Heterocyclics are usually selected. Courses in advanced inorganic chemistry and lecture and laboratory courses in colloidal chemistry may be included. Advanced courses in biochemistry, bacteriology, physics, manufacturing or hospital pharmacy, and academic pharmacy are selected to meet the student's needs. Courses in chemical bibliography and in statistics are recommended. Synthetic Drugs and Vitamins and Hormones may be elected if the student has not had equivalent courses previously. Pharmacology courses in bioassay methods may be recommended as background for those especially interested in administrative control positions. A course in Food, Drug, and Cosmetic Law and other legal material pertinent to the field is contemplated.

In general, in planning the course sequences we

attempt to utilize the facilities of any of the graduate departments of the university which appear to be applicable to the research problem or in which the student has a special interest. I think we must recognize both in our graduate and undergraduate curriculums that pharmacy is an applied science and that the fundamentals of the sciences underlying it can usually best be presented by experts in their respective fields. Applications of these fundamentals to pharmaceutical problems constitute the basis for most of our course work.

We come now to a discussion of the type of research problems which may be assigned as a basis for the thesis in this program. Although I have touched on the more formalized requirements for the degree first, I have not meant to imply that these constitute the most important part of the program. I think we would probably all agree that in any program leading to the Doctor of Philosophy degree, the research work and the thesis play a most significant part. In spite of this, however, People in industry who are in a position to employ our graduates continually stress, in conversation, the desirability of a broad educational background and seem to attach considerable significance to the variety of educational experiences to which the student has been exposed. In other words, there seems to be some thought that too great an emphasis upon the research problem in the schools may lead to such a high degree of specialization that the beginner in industry may be unable to adapt himself to the ever-changing environment in which he must carry on his work. We must admit that only in relatively rare instances does an individual find the opportunity in industry to continue his work within the strictly limited area of his thesis.

Some would use this observation as a basis for the argument that the research problems being investigated for doctoral degrees are not timely problems and that therefore industry has no incentive to support their continuation within its own departments. I think there is some truth in this contention and I have devoted considerable thought to finding ways through which analytical problems relating to new products may be assigned to graduate students. It is easy, of course, to say that one should keep up with current literature and hence have research programs under way on the newest synthetic products as they are released for medicinal use. Naturally anyone seriously interested in a graduate program of this type will be doing that to the best of his ability. The difficulty is, as most of us are aware, that before a new compound is reported in the literature, the company doing the research on it has already developed analytical methods not only for its assay but usually also for the determination of blood levels, tissue fluid levels, and other clinically important laboratory procedures. Such a situation is inevitable, of course, since the companies must protect their economic interests, and I certainly do not intend to criticize it here; nevertheless it is a condition which we must face. Sometimes these earlier analytical processes are not nearly as accurate, precise, or generally satisfactory as is desirable, especially if the product and its dosage forms are to receive official recognition; when such situations become generally known through the literature, opportunities for more timely research projects in the academic field arise. Dissemination of information about these situations on a considerably greater scale through such media as Drug Standards would be helpful to us in the academic field. Reporting the solution of problems is of course to be expected; reporting data which show that problems exist might stimulate work leading to their solution. The inclusion of academic groups, where possible, in collaborative studies such as those sponsored by the Contact Committee, the official compendia, and the Food and Drug Administration would also lead to more worthwhile projects within the schools.

Another way in which such difficulties might be partly alleviated is by the establishment of more direct working relationships within the schools between the various graduate programs. Closer coordination of the work being done in graduate programs in synthetic and analytical pharmaceutical chemistry, pharmacology, and product development might be mutually beneficial to all. Of course, where these programs are supported by grants from industry, the problem of maintaining secrecy until products or processes are protected by patents again arises. The over-all aspects of the problem of selecting important and timely research projects are of considerable importance not only to those interested in the analytical field but equally so to those interested in product development research projects on an academic scale. Perhaps no completely satisfactory solution to these difficulties exists. They can be materially lessened, however, if we in the schools who are faced with them can demonstrate our ability to make helpful contributions from time to time and if we can prove ourselves capable of maintaining the confidential character of such information as may be given us until the proper time comes for its release. If such confidential relationships prove workable, more industrial support in the form of financial aid for analytical and product development programs might be expected.

There is still a wide field for analytical research in the development of new procedures for the older drugs. By taking advantage of the more precise and more rapid analytical techniques which are available today, many of the older assays could be greatly improved. For example, if the alkaloids as a class of therapeutic agents were just in the process of being discovered, there is little doubt that the analytical processes developed for them today would be spectrophotometric or other instrumental analyses. New products of similar potency and similar dosage levels are almost always assayed by such procedures.

Separations might be chromatographic instead of the tedious processes which were originally developed. I mention this as an example since considerable work has already been done toward modernizing certain alkaloidal assays especially as they are applied to tablets, capsules, injections, and other dosage forms containing small amounts of the active ingredient. There is room for much further work of this type, and there are many other groups of older medicinal agents for which we are using antiquated analytical procedures simple because pharmaceutical analysts have been slow to adopt innovations which are by now established procedures in many other analytical fields.

In addition to the strictly analytical problems which I have just been discussing, there are always numerous problems involving stability of both old and new medicaments under various conditions. These frequently are essentially analytical in character although I recognize that they might be properly claimed by product development programs. In this area there is such a close relationship between these two fields that the problems might well be attacked by either, or perhaps more profitably by a co-ordinated effort of both. There may be some question as to whether problems such as these lead to acceptable doctoral theses. Unless there is a significant contribution either in the field of analytical methods or in improvement of the product through the use of novel pharmaceutical technique or materials, it seems to me that projects of this nature are apt to lead to theses which fall short of normally accepted academic standards. It is obviously unfair to the graduate student to allow him to undertake such a problem for his doctoral research unless he is fully aware of the uncertainty of the value of the completed project as far as a thesis is concerned.

The whole question of what constitutes an acceptable doctorate thesis is a matter subject to considerable debate. The old European idea that a significant contribution to knowledge must be made has been modified in modern educational practice in America by a re-evaluation of the meaning of the term "significant." I do not believe that we have the time to consider this subject very fully here, but I would like to voice my opinion that the research program for the doctoral candidate should strengthen his desire to do research, should introduce him to methods of planning and conducting research and evaluating the results obtained, should offer him the opportunity to do some original thinking and achieve some original results, and should develop his confidence in his own ability to pursue his ideas to their logical conclusions. If these things can be accomplished, then I'm not too worried about the immediate applicability of the results obtained or about the significance of the contribution. After all, who can judge the ultimate significance of an original piece of work?

In summary, I have attempted to point out the objectives of our program in analytical pharmaceutical chemistry, to indicate briefly the type of undergraduate training which we believe is desirable for those entering the program, and to discuss the operation of the program in terms of its course work and its research work. I would be the last to claim perfection for the program. I regard it as just getting well started; some phases of it are not yet into complete operation; and undoubtedly it will be revised and changed as time passes and more experience is gained. I heartily welcome the comments and criticisms of this group, and if any of you believe, as I do, that it is a worth-while program, I would appreciate your sending me from time to time students who are interested in this field of endeavor.

HOW DEVELOPMENTS IN RADIOACTIVITY WILL AFFECT THE TEACHING OF COURSES IN PHARMACEUTICAL CHEMISTRY

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Occasionally, in the evolution of science an entirely new field of study emerges. It is usually not possible nor is it particularly important to point out the specific time in which the new branch or offspring was born.

Gradually, as such a new field of knowledge expands in breadth and depth, longer periods of time are required to master the various small aggregate techniques and concepts which finally become of sufficient age and importance that a new field of specialization is recognized. Such, in my opinion, is the field of study which has been assigned to me for discussion this morning -- the field of radioactivity and how this area will affect teaching in pharmaceutical chemistry.

The first shipment of reactor-produced radioisotopes in August, 1946, marked the beginning of extensive application of these materials to all areas of medicine, science, agriculture, and industry. Six years later, even though tremendous progress has been made, it is known that the surface of possible uses has been barely scratched and that as yet undreamed of applications beyond the scope of present day thinking lie waiting to be utilized by those professions keeping abreast of new development in new fields of thought.

The very nature of this excellent Teachers' Seminar as I have listened to the various papers and discussions during the past week has suggested certain provocative words which seem to me to have special significance to teachers and scientists and also to the subject under discussion this morning. Among words beginning with "A" there are many which characterize the teacher and the scientist, including accuracy, application, absolute, analysis, activity, and so forth, however, there is an unusual word with special significance which I must confess is new in my vocabulary, but which I believe has some very interesting connotations. This word is agnosia. Agnosia means the inability to recognize that which we see before us.

If ever a fault plagues the scientist and the teacher, not limited of course to those in pharmaceutical chemistry but equally as applicable, this one does. The inability to recognize that which we see before us.

Agnosia was responsible for the fact that D.D.T. lay on the shelves for years before it was found to be an insecticide, that the sulfa drugs were known even longer than this before their antibacterial action was recognized, and that the effect of antibiotics was observed time and time again before their significance was grasped and utilized.

It is a continual struggle to keep agnosia at a minimum. It may be partially alleviated by all things which encourage thought on the improvement of the subject in question.

One of the greatest values of this Teachers' Seminar is that it tends to lessen agnosia. It keeps our minds on our work and causes more critical evaluation of our present-day positions and practices.

Agnosia often deters the utilization and acceptance of new fields of knowledge and yet the utilization of radioisotopes in all branches of science has shown phenominal advancement. During the first year of the isotope distribution program approximately 1,000 radioisotope shipments were made to some 150 institutions. By the end of the following five-year period, more than 18,900 shipments were made to 600 institutions.

Perhaps a better indication of the utilization of these materials in the relatively short period of time (five years) that they have been available is the number of published scientific papers describing work done with radioactive isotopes. Three years ago approximately 1,800 such papers had been presented. In August, 1951, a total of 2,200 had appeared in the literature. It is practically impossible to thoroughly understand scientific literature today without some prior knowledge of radioactivity and methods of utilization.

It is difficult to recognize and evaluate the future importance of that which we see before us in the form of radioactive utilizations. But evaluate it we must, and we must take action accordingly, if we are to attract superior students to our profession and strive to increase the prestige of the profession.

I am sure I have said more than I should about the importance of radioactive isotopes, since our next speaker is going to dwell specifically on applications for fifty minutes and, having heard him speak several times before, I know that he will impress you with their possibilities.

The question which we need to answer specifically now, as best we can, is, How will developments in the field of radioactivity affect the teaching of Pharmaceutical Chemistry?

I would like to break this discussion down into

two sections, (1) undergraduate instruction and (2) graduate instruction.

With respect to undergraduate instruction, we have discussed during the past week roughly twenty different kinds of pharmaceutical chemistry, and the importance of each in turn has been expounded emphatically. We have talked of basic chemistry courses, inorganic pharmaceutical chemistry, qualitative analysis, quantitative analysis, drug assay, industrial analytical control, organic chemistry, biochemistry, organic pharmaceutical, organic medicinal, synthetic organic medicinal, physical chemistry, instrumentation, and we have touched on the edges of many more. One must be extremely cautious about saying that we now need to add another entirely new area of instruction, because we all know that if the educational balloon is blown to the bursting point, it is necessary to remove stale air before fresh air can be added. It is always easy to suggest that we need this and that added, but is difficult to discard that which has been shown to have even the least bit of possible utilization or value. This is analagous to "an old piece of equipment" or to "junk in the attic"; it's much easier to retain it or to shift it from one place to another than it is to throw it away.

Nevertheless, fresh air must be added continually to meet the demands of present day students because they seem to have the inherent instinct of detecting and moving from the stale to the fresh. Therefore, I recommend at this time a short sniff of radioactivity as a welcome refreshment, not to be administered as a separate package, but to be dispensed along with the regular diet wherever it is convenient to do so.

Most modern texts and courses in introductory chemistry now devote one or more chapters to the subject of radioactivity. This preliminary exposure, along with what the student reads and hears about the atomic age, whets his appetite to the extent that he wonders how such materials can possibly be of value to the health professions. Radioactive iodine has been approved by the Committee on Scope for incorporation into the next U.S.P. and other radioisotopes will soon follow. Three to five one-hour lectures should be sufficient time to clarify these and other questions which need to be answered to the extent that the student will be capable of discussing the topic intelligently.

The following general outline is offered as a guide for the material to be covered in such a series of lectures.

1. Fundamentals of radioactivity (general rather than specific)
   a. Definition of terminology
      egs. Isotopes (stable and unstable), radioactive, alpha and beta particles, gamma rays, ionizing radiation, half-life, Mev., decay curve, G.M. counter, background, etc.
   b. Types and properties of ionizing radiation as emitted from radioactive isotopes
   c. Characteristics of radioactive isotopes
2. General avenues of peacetime application
   a. As sources of ionizing radiation
   b. As tracer substances
3. General advantages as tracers
   a. Specificity
   b. Sensitivity of detection
   c. Attention to complexity of details
4. Methods of detection and measurement
   a. G.M. counter (demonstrate)
   b. Photographic plate
5. Sources of supply and cost
6. Specific applications[1] to medicine, industry, agriculture, and research
7. Important sources of information
8. Short question period

Such a series of lectures is presented to the junior students at our institution as a part of the quantitative analysis course; however, the subject can be presented as a part of almost any course in pharmacy, since radioisotopes are applicable to all areas. Emphasis should, however, be placed on medical applications, since these applications are of more value and interest to pharmacy students in general.

It can be said with considerable certainty that the pharmaceutical curriculum which fails to discuss nuclear physics, radioactive isotopes, and their applications to modern living is missing one of those rare opportunities to stimulate the imagination and interest of the student.

The developments in the field of radioactivity, then, have not as yet appreciably affected the teaching of pharmaceutical chemistry at the undergraduate level and probably will not in the next three to four years; however, looking ahead to the next decade, the crystal ball points to more extensive utilization with the accompanying need for a qualified staff member to teach this area of interest. Now is the time to start building for such staff needs.

With respect to graduate instruction, an entirely different viewpoint as to the importance of such instruction must be taken.

Presumably one of the main objectives of a graduate program in our schools of pharmacy is to acquaint the student with the important research tools through which satisfactory and useful data can be obtained.

It has been stated many times, and I am in total agreement, that the range and usefulness of radioactivity as a tool of research is unsurpassed by any of the tools at our disposal with the possible exception

[1]Very excellent photographs of line drawings depicting specific applications of radioactive isotopes to medicine, research, and industry, from which slides can be made, are available from the Isotopes Division, Atomic Energy Commission, Oak Ridge, Tennessee.

of the analytical balance and the microscope. Like the analytical balance and the microscope, the use of radioactivity as a research tool is not limited to a few of the fields of research endeavor in pharmacy but is applicable to all areas.

The only real solution to providing the necessary techniques for adequate use of this tool in research lies with the colleges and universities which have the experience and facilities for making this type of instruction truly effective.

To recognize this fact and the importance of such a tool is the first step in evaluation of the instructional needs at the graduate level. Once this has been done, the next step is to establish adequate instruction and instructional facilities in the area.

Assuming that we are agreed on the importance of the area, adequate instruction might consist of two courses: (1) a three credit-hour lecture course or the equivalent on "Isotope Tracer Techniques for Biological Application" and (2) a one credit-hour laboratory course on "Radioisotope Laboratory Techniques."

The lecture course should be so designed as to give the necessary theory and technique required for the application of radioactive isotopes to biological research in general and the laboratory part should provide typical experiments giving practical utilizations in the same area.

There are very few colleges or universities offering instruction of this kind and yet the biological area is the one in which large numbers of graduate students in various divisions of these institutions are interested.

The various schools of pharmacy immediately have the problem of establishing courses of instruction in their own division or of depending upon courses taught in physics, chemistry, or comparable divisions.

If satisfactory service courses of the type desired are available in other divisions, certainly advantage should be taken of this fact.

If, on the other hand, no courses are available, if such courses are slanted toward the chemical and physical sides of application, or if they require a series of prerequisite courses to the extent that the student must spend valuable time in extensive preparation, strong consideration should be given to the establishment of course material suitable to the needs of the graduate students in the various areas of pharmacy. Surprisingly enough, these needs turn out to be almost identical with the needs of graduate students in most of the biological sciences, including biology, biological chemistry, agronomy, agricultural chemistry, horticulture, entomology, animal husbandry, and veterinary science.

To make my point more emphatic in this regard, I would like to explain the situation at Purdue University in the area of radioactive isotope instruction, not because it is Purdue, my own institution, but because it is the situation with which I am most familiar. Five graduate courses are offered in the field of nucleonics in the Physics Department, two are offered in the Chemistry Department, and two, one lecture and one laboratory course, are offered in the Pharmacy School. The courses in the Pharmacy School are directed toward biological application, whereas, the other courses are not. Since the spring of 1948, 189 graduate students have obtained credit in the Pharmacy School lecture course. Of these, 74 were pharmacy graduate students and 115 were from other divisions of the University. The breakdown of students enrolled is as follows:

University Division	No. Enrolled Since 1948	
Pharmacy	74	(39%)
Biology	57	
Chemistry	21	
Agricultural Chemistry	13	
Animal husbandry	6	
Horticulture	5	
Agronomy	4	
Veterinary science	3	
Chemical engineering	2	
Home economics	2	
Entomology	1	
Physics	1	
	189	

The laboratory course has been offered for the past three semesters. A total of 63 students have been enrolled, and the division distribution is about the same as that given for the lecture course.

These courses are offered in the pharmacy curriculum because the desired material is not offered elsewhere in the University and it was not considered wise to wait for others to initiate such important instruction. As a result, these courses are now service courses for many other divisions of the University as well as providing adequate instruction for our own students.

Such a service course has many advantages which are not readily apparent on the surface. Not the least of these advantages is the fact that interdepartmental co-operation possibilities are increased and the departmental prestige correspondingly raised in the eyes of comparable areas of research endeavor. Bargaining power is always increased in direct ratio to what can be offered in return.

In addition, such a situation enables justification for increased personnel and equipment budgets. The equipment obtained may be used for research endeavor as well as for instructional purposes, and so forth.

These factors may seem trivial, but when we look ahead to the growth and development of superior graduate instruction and facilities in our schools of pharmacy, they become all-important.

I have already mentioned that there are very few educational institutions at the present time offering instruction concerned with the biological applications of radioactivity. Since this is true, in the

belief that a brief outline of suggested course content may be of some value to those contemplating initiation of such instruction, the following information is presented as a working guide for organizing important lecture material.

Outline of Content of a Lecture Course in Isotope Tracer Techniques for Biological Applications
(presented concurrently with a laboratory course)

Reference Text: Kamen, M.D., RADIOACTIVE TRACERS IN BIOLOGY, New York; Academic Press Inc., 1951

1. Important literature sources on isotopes
2. Fundamentals of radioactivity (general)
   a. Definition
   b. Types and properties of radiation
   c. Characteristics of radioisotopes
3. General discussion of importance to medicine, agriculture, research, and industry
   a. As sources of ionizing radiation
   b. As tracer substances
4. Radiation hazards (general)
5. Effects of ionizing radiation on matter
6. Methods of measurement and detection (instrumentation)
7. Necessary correction factors in various methods of measurement
8. Fundamental decay law
9. Units of radioactivity
10. Absolute disintegration rates
11. Radioactivity standards
12. Szilard-Chalmers reaction
13. Statistical treatment of results
14. Tracer methodology
    a. Requirements of a radioactive label
    b. Carrier techniques
    c. Isotope dilution analysis
    d. Activation analysis
15. Useful and available isotopes
16. Isotope procurement and cost
17. Labeled compounds (procurement and cost)
18. Autoradiographic technique
19. Radiography technique
20. Radiation hazards (specific)
    a. Contamination and health
    b. Units of radiation dosage
    c. Maximum permissable exposures
    d. Health physics instrumentation
    e. Procedures for control
21. Fundamentals of radioactivity (specific)
    a. Atomic and nuclear structure
    b. Fundamental particles and properties
    c. Mass energy relationships
    d. Methods of radioactive decay
22. Production of radioisotopes
    a. Cyclotron and allied instruments
    b. Atomic pile
    c. Nuclear reactions
    d. Capture cross-section
23. Important radioisotopes for biological application (C^{14}, I^{131}, P^{32}, S^{35}, etc.)
24. Preparation of labeled compounds
    a. Synthesis
    b. Biosynthesis
25. Specific applications to medicine, industry, agriculture, and research

Outline of Laboratory Instruction in Radioisotope Tracer Techniques
(presented concurrently with a lecture course)

Each laboratory period is preceded by a short lecture (one-half hour) on the day's experiment, and visual teaching aids are shown at several of the laboratory sessions. (See list below[2].) Two general lectures are given preceding any experimentation. These are (1) Instructions for Procedure Concerning the Control of Radioactive Isotopes and Associated Hazards and (2) General Operating Instructions for Scalers.

Experiments

1. Decontamination
2. Determination of the operating potential of the G.M. counter
3. Preparation and measurement of a sample of radioactive material
4. Determination of backscattering
5. Preparation of an Uranium Standard

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[2]List of training films on radioactivity and source of supply.

I. The following fourteen films are available on loan from the Army Signal Corps at the various Army Area Headquarters as follows: First Army, Governors Island, New York; Second Army, Fort Mead, Maryland; Third Army, Fort McPherson, Georgia; Fourth Army, San Antonio, Texas; Fifth Army, Chicago, Illinois; Sixth Army, San Francisco, California. (All are 16 mm. sound, black and white.)
   1. Fundamentals of Radioactivity
   2. Properties of Radiation
   3. Practical Procedures of Measurement
   4. Methodology
   5. Principles of Radiological Safety
   6. Practice of Radiological Safety
   7. Biological Effects of Radiation
   8. Medical Research
   9. Diagnosis
   10. Therapy
   11. General Sciences
   12. Industry and Engineering
   13. Agricultural Research
   14. Stable Isotopes

II. Atomic Physics - An authoritative film on the history and development of atomic physics; 90 minutes, 16 mm. sound; Source: F. S. Henck, Public Information Offices, U.S.A.E.C., Oak Ridge, Tennessee

6. Determination of the half-life of I^{131} and P^{32}
7. Determination of the resolving time
8. The feather analysis
9. Purification of an isotope by volatilization
10. The preparation of I^{128} and Ag^{108} by the Szilard-Chalmers reaction
11. The use of miscellaneous monitoring instruments
12. The determination of the biological uptake of an element using external detection of a radioactive label.
13. The preparation of carrier-free P^{32} (coprecipitation)
14. The separation and purification of radioelements by ion-exchange
15. The determination of the overall efficiency of the counter arrangement and the absolute activity of a sample
16. Preparation of a self-absorption curve. ($BaSO_4$)
17. Direct isotope dilution analysis
18. Inverse isotope dilution analysis
19. Quantitative analysis with a radioindicator
20. Biological distribution of P-32 in the rat
21. Autoradiographic techniques using plant and animal tissue
22. The separation and measurement of Fe^{59} by electrodeposition
23. The use of the Lauritsen electroscope

This information and the general course outlines are offered only as a guide for those who may wish to establish such instruction in the future. The developments in the field of radioactivity, then, in my opinion, have already dictated the need for graduate instruction in this field for graduate students in the various areas of pharmacy. Whether such instruction is offered in the area of pharmaceutical chemistry or some other area is entirely incidental as long as a satisfactory approach to the subject is made. A rare opportunity for pharmaceutical research recognition presents itself, however, in those institutions which do not have such instruction available.

To be a successful training and research organization demands more than possession of a massive name-plate over the door. It demands the meeting of challenges, it needs imagination and courage, and the ability to recognize that which we see before us. Above all it demands that the organization be a leader in the new areas of endeavor and thereby keep a jump ahead of the procession.

It is well to remember that the advancement and recognition of any organization or field of endeavor is made primarily through the application, without undue hesitation, of extra special effort in the realm of the undeveloped and unknown areas.

THE PHARMACIST AND RADIOACTIVE PHARMACEUTICALS

Dr. D. L. Tabern

Head, Department of Radioactive Pharmaceuticals, Abbott Laboratories

My report to you concerns an anomalous situation, one with which you as pharmacists should, and will, be directly concerned. The first radioisotopic material was given to humans by the group at California in about 1936. The real use of such material, however, did not start until some ten years later, when pile-produced radioisotopes were first distributed to properly allocated groups by the Isotope Division of the Atomic Energy Division. Since that time more than twenty thousand such radioisotope shipments have been made. Some 75 per cent of these have gone into medical and biological fields. How much material has actually been used in humans, it is difficult to say, but the estimate has been made that there are somewhere between 500 and 1,000 iodine uptake determinations made with I-131 in the United States each week. I do know that something of the order of 8 curies of activity, or the equivalent of 8 grams of radium, in Au-198 alone, is being produced by our organization each week, and certainly the great majority of this is going into human therapy. There is also the case of P-32, which has become the standard treatment for polycythemia-vera and certain types of lukemia.

All of this has evolved on the theory that these materials are strictly experimental drugs, and until we submitted several products to the Food and Drug Administration some months ago, that regulatory body had not even taken official cognizance of such distribution.

Moreover, these materials had, almost without exception, gone to the departments of radiology or radiobiology of the various hospitals and had completely by-passed the hospital pharmacy.

The reason for this was, of course, the simple fact that pharmacists by and large had not had the training in mathematics, physics, and other theoretical subjects which would have enabled them to take an active part in such radioisotope handling.

Another very significant factor has been that these materials are very hazardous to handle and process. To take the material as produced by Carbide and Carbon at Oak Ridge, to reassay it, to purify it if necessary, to sterilize it, and to dispense it, in containers suitable for use, required a somewhat elaborate physical setup. Moreover, it required personnel trained in this new field. The possibility of contamination, of accidents, and so forth, places it totally outside of the hospital pharmacy, even a manufacturing hospital pharmacy.

Some five or six years ago a number of us here at Abbott Laboratories decided that we certainly wished to make use of radioisotopes as a research tool. As soon as we were actively engaged in such projects, we were asked to assist various university and hospital research groups in preparing compounds and material for them. The next step was a very logical one, whereby there was organized within the Abbott organization a complete and semi-autonomous Department of Radioactive Pharmaceuticals. This has gradually been staffed with trained personnel. The members of the staff have been kept up to date by added specialized training, and physical facilities have been increased, from time to time, to keep pace with demand. So rapidly has this business of "Radioactive Pharmaceuticals" grown, that our shipments for 1951 were three times those of 1950, and today we are making almost half as many shipments as the peacetime shipments from the original Oak Ridge production unit.

Obviously, we approached this matter as chemists and as members of a long-standing pharmaceutical organization. We early decided that all material that we send out would be sterile, pyrogen free, and packaged in the same type of glass and under the same conditions as the most delicate of other pharmaceutical products. We little realized at the time how many other problems would be necessitated by the radioactivity of the material, by its short half life, and by the health physics aspects around our own laboratory.

To date at least, we are still the only pharmaceutical organization engaged in work of this type. We purposely kept the project within the Research Department because there we could be assured of the most careful and skilled, as well as technically trained, individuals. In this way we avoided, at least for the moment, the question of making income meet the actual cost of preparation. I do wish to give every credit to all of the members of our Board of Directors and to the others of the company who have not only heavily subsidized this project, but have given routinely of their time and effort to help us make it a success.

For instance, we have the services of our fermentation group for the carrying out of biological syntheses, we have the active co-operation of our pharmacologic group in testing for such things as pyrogens, and we routinely have all of our samples tested for sterility by our Department of Bacteriology. Our shops have constructed much original and valuable specialized equipment.

Characteristics of Radioisotopes

It is high time that we took a look at radioisotopes themselves, and some of the many things that can be done with them in research institutions, in hospitals, and in clinics. In Table I we see a simple listing of some of the more important radioisotopes. There are some 760 radioisotopes known, but of this number, not over 15 or 20 offer much promise by way of human application. One reason for this is to be found in the second column of this table.

TABLE I

Isotope	Half life	beta mev		gamma mev	
K-42	12.4 hr	2.04	3.58	1.5	
Na-24	14.8 hr	1.39		1.38	2.75
Br-82	34.0 hr	0.465		1.35	etc.
Au-198	2.7 d	0.97	0.6	0.41	
I-131	8.0	0.60	0.31	0.638	0.37
P-32	14.3 d	1.71		none	
S-35	87.1 d	0.17		none	
Ca-45	180 d	0.26		none	
Co-60	5.3 y	0.31		1.16	1.32
C-14	5700 y	0.15		none	
Fe-59	46 d	.46		1.3	

By the term "half life" we mean the time required for one-half of the sample present at the start of the observation to have been lost due to natural radioactive decay. If this time is very short, as in the case of potassium-42 and sodium-24, it is almost impossible to process and to keep the material on hand for any more than purely research purposes. On the other hand, you see that carbon-14 has a half life of something more than 5,000 years, and therefore if a person takes in carbon-14 and if it is not eliminated promptly, it can continue to cause radiation damage to that person's body. Actually, that is not the whole story, because if, for instance, that carbon-14 is in carbon dioxide, a very high percentage would be respired out again within a few minutes, and only a very minute fraction would ever be taken into the body metabolism at all.

The point that we are interested in, however, is that for practical purposes such a radioisotope must have a half life of between 2.7 and 80 days, and the number of such isotopes is definitely limited.

A second point of interest is that the number of grams to give a millicurie, (and a millicurie, without going into a strict definition, may be considered as an average amount for diagnostic or therapeutic purposes), is infinitesimally small. Therefore, customary assay procedures are quite without significance, and reliance must be placed upon new radiochemical determinations.

The last two columns of Table I show an equally important point; namely that radioisotopes give at least two types of radiation -- beta and gamma. (Some individual isotopes give only 1 type.) These are distinguished, among other criteria, by their penetration. A gamma ray, which is essentially similar to an X ray, will go through many feet of tissue without necessarily losing much of its energy to that tissue. On the other hand, the range of beta particles is only a matter of a few millimeters, and these particles give up all of their energy in that very narrow region. The isotope user, therefore, has in beta radiation, a tool which is not usually available to the radiologist, and some very interesting new developments are coming out of the use of beta rays, as we shall see in the case of the thyroid, and in the case of the use of gold, and so forth.

Clinical Usefulness of Radioisotopes

In order to clarify and simplify (and perhaps oversimplify) these situations, I have prepared a number of other tables, simply pointing out the ways in which radioisotopes are used. For instance, in Table I one may use them to very quickly and usually very accurately obtain certain clinically valuable information. Some of this information can be obtained by other techniques, but most of it only by isotope methods.

As I am sure you know, iodine is picked up quite extensively by the thyroid and slowly converted there to various products including the end product, or thyroxine. The original use of such studies was to determine how actively the thyroid takes up the iodine with the idea of thus being able to calculate the amount of Iodine-131 necessary to irradiate the throid. If this dose is properly adjusted, it becomes possible to destroy all or part of the thyroid tissue just as successfully, and certainly more smoothly for the patient, than would be the case with surgery. It has been estimated that in those institutions where radioiodine is available, some 40 to 50 per cent of the treatments for hyperthyroidism now consists of the administration of Iodine-131. (There are certain presumed contraindications, which certainly are not within the scope of this presentation.) It has recently been found, and checked by many institutions, that these thyroid uptake studies are, in reality, a much better indication of the basal metabolic state of the individual than the older and very unreliable basal metabolic rate determinations. Today many of the iodine uptakes are being done for this purpose. Recently it has been possible, by an ingenious mechanical device, to very accurately map the location and the size of the thyroid.

I think that most of you know that all such measurements, since iodine gives off gamma rays which penetrate outside the body in straight lines, are made with the counting tube a matter of some centimeters from the patient, and with no inconvenience, and no apparent harm to him. In fact, I think I am

quite safe in saying that it has never been shown that a well-chosen tracer dose of iodine has ever done the slightest harm to any patient.

One of our most interesting products was developed with this sort of a thing in mind, and I think it illustrates the application of simple pharmaceutical ideas to this new field. This "tracer solution," as we call it, is prepared and sent out during a given week, but its use is not to start until Monday of the following week. The activity, that is the radioactivity, is always exactly 25 microcuries per cc as of that Monday. In other words, if the hospital or the thyroid clinic of that hospital is employing radioiodine (25 microcuries) for a tracer dose, it is necessary to withdraw from that bottle exactly 1 cc and give it to the patient either orally, or we believe better, intravenously. Each bottle is accompanied by a chart which shows the decay, and one may read on that chart that if a dose is to be given on Thursday, exactly 1.25 cc would be withdrawn to give exactly that same dosage. Again, I would like to emphasize that these materials are all sterile, pyrogen free, and packed in little containers surrounded by small shields so that they can be handled right in the laboratory. Thus the operator suffers no hazardous exposure to radiation.

TABLE II

A. Quickly and Accurately Obtain Clinically Valuable Information

(1) Thyroid Uptake & Excretion Studies (Tracer Iodine)
(2) Thyroid Mapping (I-131)
(3) Plasma Volumes (P-32, Cr-51, IHSA)
(4) Red Cell Volumes (Cr-51, P-32, Fe-59)
(5) Total Blood Volumes (IHSA)
(6) Thiocyanate Spaces (KSCN)
(7) Sodium & Potassium Spaces
(8) Circulation Times (Na - IHSA)
(9) Cardiac Outputs (Na - IHSA)
(10) Liver Circulation ($CrPO_4$, IHSA, etc.)
(11) Methionine Incorporation

Blood Volume Determinations

So far, we have referred simply to the inorganic compounds of radioisotopes, but very obviously they may be combined as a part of organic molecules. As you know, the blood protein or serum albumin contains residues which may be iodinated with radioactive iodine. If the amount of iodine thus added is kept below a critical level, it thus becomes possible to, in effect, tag the blood albumin of a given patient.

In the early days a somewhat similar thing was done with the red cells by tagging them and by allowing them to stand for some hours with radioactive phosphorus. In the case of the albumin the tagging is already done before the hospital receives the material.

This material which we call Iodinated Serum Albumin (IHSA) is being very extensively used for plasma volume or blood volume determinations. A small amount, containing a totally harmless dose of activity, is withdrawn from the bottle, diluted with saline, and given to the patient intravenously. After a few minutes' mixing, a sample of blood is withdrawn and compared with the original sample, under a Geiger counter. The dilution thus shown represents dilution in the blood. Colors do not interfere, and the whole measurement need not take more than a relatively few minutes. If one centrifuges and uses the plasma fraction, one obtains the plasma volume. If one does not centrifuge, but uses the whole blood, one arrives directly at the total blood volume. Unlike the use of Evans Blue, it becomes possible to repeatedly determine blood volumes on the same patient and this alone has saved a number of lives.

This is not all that one can do now that he is working with radioactive materials. I have just mentioned the possibility of tagging the red cells with phosphorus and the albumin with iodine. Each of these has radiation characteristics of itself alone, so that it becomes possible to determine red cell volume, plasma volume, and total blood volume upon the same small sample of a few cc's of blood. No wonder that this method has shown tremendous growth in the past year or so!

The remainder of this Table II mentions a number of other very interesting uses in this field of clinical studies. Unfortunately, time does not permit individual discussions and I will have to refer you to references in literature, many of which we have summarized in convenient forms for you.

Tumor Localization

It has been known that tumors, because of their more rapid protein turnover, take up certain materials like P-32. Employing a very fine Geiger counter, which may be inserted directly in brain tissue, it has been possible in many instances, to delineate a tumor which exists there, and to thus assist the surgeon in knowing when he has excised all of the tumor tissue. We have been much more interested in another aspect, that of a diagnostic method which would enable one to determine if a tumor was present before operation, and if so, to give an accurate idea of its size and location. Here again, we have to have recourse to a gamma emitter like iodine, and the first real development in this connection was made by Dr. George Moore who found that the dyestuff diiodofluorescein was selectively taken up by brain tumors. By a suitable directional counter, he and others were able to use this method with an accuracy of somewhere between 70 and 95 per cent. Unfortunately, rather rapid work was necessary and certain institutions found the

technical difficulties beyond their skill. More recently Dr. Moore found that this same material which we have been supplying to him in another connection, (the determination of blood volumes) also localized in brain tumors, and fortunately stayed there for a much longer time. As a result, this IHSA has practically become the standard material for such brain tumor localizations, and the reports, which are just beginning to reach the point where they are statistically significant, certainly justify the earlier enthusiasm for this material.

TABLE III

B. Accurately Localize Many Brain Tumors

(1) From Without Skull (I-131, DIF, & IHSA)
(2) By Probe Counter During Operation (P-32)

Perhaps it would be wise to add here, parenthetically, that such synthetic methods are obviously beyond the scope of hospital groups, not to mention the cost of material if prepared in small lots.

It has been possible for us to prepare these materials in a very pure state, and to keep stocks on hand at all times so that with air express delivery, it becomes possible to secure material for emergency use in addition to the regular stocks used by many hospitals continuously.

Other Research Uses

In Table IV it is emphasized that this usefulness of radioisotope tagged compounds extends far into the research field. We have spent a great deal of time developing methods and are currently serving as essentially the single source of supply for sulfur tagged methionine, cystine, glutathione, penicillin, and other sulfur containing amino acids. Such tagging has many advantages over the use of C-14. It is much cheaper and the activity does not become as widely distributed among other body constituents. Most important of all, these experiments can, wherever necessary, be transferred to humans or carried out in them, which is quite out of question with C-14. Of the ten uses listed in this table, I would like to mention only two specific ones.

TABLE IV

C. Investigate Various Problems in Physiology, Pharmacology & Bacteriology.

(1) S-35 Methionine, Cystine, Glutathione, Yeast cells, etc.
(2) S-35 Pentothal, Sucaryl, Insulin, etc.
(3) I-131 Tagged Thyroxine, & Intermediates, etc.
(4) Antigen - Antibody Studies with Tagged Globulins
(5) S-35 and I-131 Fibrinogen
(6) Iron Metabolism - Red Cell Life
(7) Fat Absorption and Metabolism
(8) Mechanism of Antibacterial Action (S-35 Penicillin, etc.)
(9) Dental Problems
(10) Carcinogens, Antimetobolites, Steroids

We have prepared thyroxine approaching in activity pure radium, and with this it is possible to measure quantitatively as little as 10^{-9} milligrams of activity. Such studies are contributing very materially in some twenty institutions throughout the country, in an elucidation of the long disputed mechanism of thyroid action.

One of the most unique things that we have is sulfur tagged yeast cells. It has recently been found that if these are fed, or hydrolized and injected, the radioactivity is usable by the animal or by the human body, and all proteins of the body become tagged. The first of these are the blood proteins. This particular work was directed towards the labelling of fibrinogen which was very successfully accomplished.

Tracer Studies

I know you must have seen in the Sunday Supplements some rather grandiose claims made for the value of the so-called tracer method using radioisotopes. There have indeed been some very astounding results from such studies, but on the other hand the results in the study of drug metabolism as such have been frequently disappointing.

To make a long story short, it has been found, beyond question, that most drugs do not go preponderantly to the sites where they exert their action. For instance we tagged both Nembutal (N-15) and Pentothal (S-35) and studied their metabolism; both are broken down quite completely in the body and neither localizes to any significant extent in the central nervous system.

In the case of Pentothal, metabolism was found to be unbelievably complex, indication being that as many as 11 different compounds were formed from it in the body. It was confirmed quite definitely that not only is the destruction rapid but also that alternative routes, namely the kidney and the liver are available, each of which takes over when the other does not happen to be functioning properly. In other words, for the practical safety of this widely used intravenous anesthetic, it did provide quantitatively the evidence for which we had hoped.

In another instance we really did not ask so much of the experiment. What we wanted to know was about the excretion of the new sweetening agent Sucaryl (sodium salt cyclohexyl sulfamic acid). We were able to show that here the material was not metabolized in any sense but excreted completely unchanged, and that even in large dosages a very considerable amount (up to 75%) was excreted within 24 hours and most of the remainder within 48 to

60 hours. This work was one of the reasons why all restrictions have been removed on the quantity of Sucaryl which may be used by a patient in any given day. I do believe this represents very valuable results which it had not been possible to obtain by several years of work with ordinary chemical methods.

I could go on and enumerate in detail other instances of this absence of localization in the organ where the physiological effect is assumed to take place. For instance, Procane does not go to the central nervous system; estrogens, in general, are not localized but are rather rapidly metabolized. Carcinogenic agents are likewise excreted almost quantitatively within a few days. All of this raises many more questions than it has answered, namely, concerning the way in which drugs act. Obviously it must be a matter of very selective interaction between the drugs and some enzyme mechanism, but since we know so little about enzymes and their interactions, we are really faced with a whole new set of problems which will, apparently, take much longer to answer than we had originally expected.

Radiation of Malignant Areas

Early in this presentation we mentioned the radiation effect obtainable from radioisotopes and compounds containing them. Everywhere I go I find astonishment at the progress which has been made in this particular field during the past three years. I previously mentioned that appropriate dosages of I-131 localize there and destroy selectively the thyroid tissue. Because of the very short range of the betas, not even the parathyroid which lies immediately adjacent to the thyroid is damaged. I think that this itself is very clear evidence that isotopes are not simply another form or radiation, especially in compound form, but possess many unique possibilities as yet hardly realized.

TABLE V

E. Selectively irradiate with either beta or gamma rays various hyperplastic areas, tumor tissues, and even lymph nodes, without undue damage to surrounding areas.

(1) Polycythemia and Certain Lukemias
(2) Hyperactive Thyroid (I-131)
(3) Some Thyroid Tumors (I-131)
(4) Unoperable Tumor Masses (Au-198, $CrPO_4$ & Co-60)
(5) Metastases from Ovarian Tumors (Au-198)
(6) Prostate Tumors (Au-198)
(7) Lung Tumors (Colloidal Particles)

Unfortunately, nature has given us such an illustration, and then failed to provide more actual examples. For instance, the amount of diiodofluorescein or serum albumin which tumors take up is not sufficient by a factor of many thousand fold, to induce radiation destruction of these tumors.

Lacking such localization, Hahn very courageously attempted, as had a few others before him, the direct injection of such radioactive materials into the tumors themselves, where these are, or can be made, mechanically available. You may very well ask why such injection can be carried out, but the tumor itself cannot be removed. There are frequently many medical reasons that obviously I as a chemist and you as pharmacists cannot be concerned with.

In this field the half life of the isotope, the type of radiation, the cost, and the ways in which it can be prepared, are all of critical importance.

It so happens that ordinary metallic gold when placed in a nuclear reactor picks up neutrons much more actively than any other common substance and is converted thereby to another gold (198) which has a half life of 2.8 days and gives 95 per cent beta rays and 5 per cent gamma rays. It may be converted to a colloid and such colloidal solutions are reasonably stable if properly prepared and sterilized. Moreover, once placed mechanically in any given tumor they tend to remain there permanently. The short half life of the gold automatically takes care of the problem of the removal. The fact that most of the rays are beta does limit the radiation destruction to a quite circumscribed area. This material has been rather widely used in such tumor infiltration, but as of the last two years this has been more or less overshadowed by a rather unexpected development coming as the result of some work of Dr. J. H. Muller in Switzerland.

Many cases of ovarian and similar tumors develop metastases, and these cause the accumulation of huge quantities of ascitic fluid in the peritoneal cavity. This rapidly drains the protein stores of the individual, and the patient frequently becomes a hopeless individual declining on a rather rapid course. If into the peritoneal cavity of such a patient, radioactive gold is given in amounts of the order of 50 to 150 mc, the effect is not so much on the tumor masses themselves as upon the tumor cells floating free in the ascitic or the walls of the cavity which are hyperactive in secreting this ascitic fluid. The principal immediate effect is that of destroying the secretory action without producing serious radiation sickness to the patient. I want to emphasize that this treatment is purely palliative, and most patients have gone on to ultimate death, but in the meantime, some 50 to 60 per cent have been restored to a comfortable, and occasionally to a reasonably normal, life until very near the fatal termination. This is certainly not all that we want, but it is more than the radiologist has been able to do for this very desperate and very pitiful class of patients.

As Goldie has recently shown, this gold at the same time does destroy the tumor cells in the ascitic fluid,

and all of us are hoping that some day it will be possible to diagnose such cancers early enough so that gold can be used to destroy the actively growing small centers before they have had an opportunity to become resistant to gold radiation.

Next month there will be published an article on the use of gold in prostate tumors. When one realizes that there are supposed to be some three million actual or latent prostate tumors in the U. S., I think one can easily visualize the possibilities in such a method even if it can only be applied in 10 or 20 per cent of the cases. It suffices to say here that the results to date look extremely encouraging.

I should simply mention in passing that radiation of the blood producing elements by P-32 is today the standard and certainly the most effective treatment for polycythemia vera and seems to be at least as good as any other treatment in certain chronic myelogenous leukemia cases.

I could go on much longer citing very interesting new developments, and giving some of the theoretical background, but I think that I have said more than enough to emphasize that radioisotopes are already a very important part of diagnosis and therapy in many leading hospitals.

Perhaps I should say a word about radioisotope facilities required for proper hospital use. The original idea of the hospital isotope unit centered about a rather extensive "hot" laboratory. Such is still desirable in large research institutions. Fortunately, the ability on the part of hospitals and other allocated groups to procure these materials from a secondary supplier all finished, packaged, standardized, and ready for use, largely does away with this requirement for the average institution.

In other words a room, or two rooms, preferably somewhat removed from the usual X-ray equipment, is sufficient in the way of space. One of these can be fitted up as a handling room simply with a good sink, a ventilating fan, and a work table or bench with a stainless steel top. A few lead bricks, or even iron bricks, and remote pipetting equipment are all of the mechanical devices urgently needed.

If such materials are obtained in assayed form, A. E. C. does not require the purchase of assay and extensive handling equipment. Under these conditions the total cost including the above furniture, equipment, monitoring devices, and so forth, need not exceed $2,000. When one considers the many things that can be done for the hospital with such a unit, it actually represents one of the most economical ways of obtaining necessary valuable clinical information.

The A. E. C. has just released new regulations which will materially widen the range of facilities under which radioisotopes may be used by individuals adequately trained to employ them. Such training must be obtained by working as an integral part of a unit already employing these same radioisotopes.

Another very significant and very recent development has been the appointment of the first member of the pharmaceutical profession, Dr. John Cristian, of Purdue University, who proceeded me as a speaker, to the distribution committee of the Isotope Division, A. E. C. This is one of the many steps being taken to recognize that radioactive materials, especially when used in hospital practice, are radioactive pharmaceuticals. And they must conform to exactly the same high standards of purity, sterility, and pharmaceutical quality, as any other material used in that hospital. In fact, because of the many unknown factors involved, I think that the standard should be even higher if possible. It is to this end that we have dedicated much of our energies and much of our efforts.

In line with Dr. Christian's position on the Distribution Committee of the Isotope Division, I would like to suggest that the pharmacist in each hospital employing radioisotopes take an equally active interest in this new form of medication. As I have stressed before, he will not want to personally take the responsibility for synthesis, preparation, or even assay. These things can be done so much more effectively and so much more certainly by a well-established pharmaceutical house. On the other hand, if the pharmacist sits as a member of the Isotope Committee at his hospital, he can point out the necessity for maintaining these standards and assist the other members of the isotope team in seeing that these are procured, received, and passed on to the proper individuals, efficiently and effectively.

PROGRAM

TEACHERS' SEMINAR ON PHARMACEUTICAL CHEMISTRY

Amphitheatre, Rackham Building
University of Michigan, Ann Arbor

July 7 to 12, 1952

Monday Morning, July 7

9:00 Registration, Lobby of Rackham Building

9:30 Opening Session - F. F. Blicke, presiding

Welcome and Statement on Objectives of the Seminar - Tom D. Rowe, University of Michigan

9:45 Teaching Patterns in Pharmaceutical Chemistry - R. A. Deno, American Council of Pharmaceutical Education

10:15 Discussion

10:30 Intermission

10:45 The Basic Chemistry Courses as Taught in a University Chemistry Department — Leigh C. Anderson, University of Michigan

11:05 Discussion

11:15 Basic Chemistry Courses as Taught in a Department of Basic and Pharmaceutical Chemistry - Ray S. Kelley, Massachusetts College of Pharmacy

11:35 Discussion

11:45 Lunch

Monday Afternoon, July 7

J. Allen Reese, presiding

1:15 Improving the Effectiveness of College Teaching - James B. Edmonson, University of Michigan

1:45 Discussion

2:00 Intermission

2:10 Teacher Training for Pharmaceutical Chemistry - Lloyd E. Blauch, U. S. Office of Education

3:00 Discussion

3:20 Tour of College of Pharmacy, Hospital Pharmacy, and Student Health Service Pharmacy

Tuesday Morning, July 8

J. B. Burt, presiding

9:00 The Introductory Course in Chemistry - Jacob Cornog, University of Iowa

9:30 Discussion

9:45 Screening of Students for the Introductory Courses in Chemistry - J. H. Hodges, University of Michigan

10:15 Discussion

10:30 Intermission

10:40 A Decade of Devotion to Pharmaceutical Education - W. Paul Briggs, American Foundation for Pharmaceutical Education

11:30 Discussion

11:45 Lunch

Tuesday Afternoon, July 8

L. C. Zopf, presiding

1:00 The Course in Inorganic Pharmaceutical Chemistry - J. E. Orr, University of Utah

1:45 Discussion

2:00 Intermission

2:10 A Course Combining Quantitative and Qualitative Analysis - P. F. Weatherill, University of Michigan

2:30 Discussion

2:40 Motion Pictures:
"The Analytical Balance and Its Use"
"Techniques of Titration"

3:15 Demonstrations, College of Pharmacy

Wednesday Morning, July 9

L. M. Parks, presiding

9:00 Should Quantitative Analysis and Drug Assay Be Given as a Unified Course - R. S. Kelley, Massachusetts College of Pharmacy

Wednesday Morning, July 9 (Continued)

9:30 Discussion

9:45 Relationships between Drug Assay and Manufacturing Pharmacy - Melvin W. Green, University of Wisconsin

10:15 Discussion

10:30 Intermission

10:40 Undergraduate Instruction Needed in Analytical Pharmaceutical Chemistry for Industrial Analytical Control - Fabian Maurina, Parke, Davis and Company

11:10 Discussion

11:45 Lunch

Wednesday Afternoon, July 9

R. A. Deno, presiding

1:00 A One Semester, Six Credit Hour Course in Introductory Organic Chemistry - J. O. Halford, University of Michigan

1:20 Discussion

1:35 Scope Objectives and Applications of a Course in Biochemistry - H. B. Lewis, University of Michigan

2:05 Discussion

2:20 Intermission

2:30 Industry's Requirements for Pharmaceutical Research Personnel - Max Tishler, Merck and Company

3:15 Discussion

3:30 General Discussions on Basic Chemistry Courses in the Pharmacy Curriculum

4:00 Demonstrations, College of Pharmacy

Thursday Morning, July 10

F. F. Blicke, presiding

SYMPOSIUM: Teaching Organic Pharmaceutical Chemistry

9:00 Prerequisites, Objectives, and Scope of the Courses in Organic Pharmaceutical Chemistry - George L. Webster, University of Illinois

9:25 Discussion

9:35 Organic Chemistry and Organic Medicinal Products as a Combined Course - E. V. Lynn, Massachusetts College of Pharmacy

9:55 Discussion

10:05 Intermission

10:15 Teaching the Chemistry of Synthetic Organic Medicinal Products - Walter H. Hartung, University of North Carolina

10:40 Discussion

10:50 Observations on the Teaching of Organic Pharmaceutical Chemistry - Ole Gisvold, University of Minnesota

11:15 Discussion

11:45 Lunch

Thursday Afternoon, July 10

F. F. Blicke, presiding

SYMPOSIUM (Concluded)

1:00 Teaching the Chemistry of Organic Medicinal Products Using a Pharmacological Classification - J. H. Burckhalter, University of Kansas

1:25 Discussion - L. A. Woods, University of Michigan

1:45 Teaching the Chemistry of Organic Medicinal Products Using a Chemical Classification - G. P. Hager, University of Maryland

2:10 Discussion

2:20 Intermission

2:30 Laboratory Work in the Chemistry of Organic Medicinal Products - John B. Data, Purdue University

2:50 Discussion

3:00 Where is the Pharmacy of Organic Medicinal Products to Be Taught? - L. F. Tice, Philadelphia College of Pharmacy

3:25 Discussion

Thursday Night, July 10

Walter Hartung, presiding

7:30 Recent Developments in Analytical Pharmaceutical Chemistry - W. W. Hiltie, Eli Lilly Company

8:15 Discussion

8:30 Recent Developments in Organic Medicinal Products - G. Rieveschl, Jr., Parke, Davis and Company

9:15 Discussion

Friday Morning, July 11

L. F. Worrell, presiding

9:00 Teaching Physical Chemistry and Its Pharmaceutical Applications - T. Higuchi, University of Wisconsin

9:30 Discussion

Friday Morning, July 11 (Continued)

9:45 Teaching Instrumentation as a Separate Course - F. M. Goyan, University of California, presented by D. H. Murray, Ontario College of Pharmacy

10:15 Discussion

10:30 Intermission

10:40 Co-ordination of the Courses in Basic and Pharmaceutical Chemistry - L. M. Parks, University of Wisconsin

11:10 Discussion

11:45 Lunch

Friday Afternoon, July 11

Ole Gisvold, presiding

1:00 Personnel and Facilities Required for Graduate Programs - G. B. Beal, Mellon Institute

1:45 Discussion

2:00 The Need for Graduate Programs in Analytical Pharmaceutical Chemistry - J. L. Powers, National Formulary Committee

2:40 Discussion

3:00 Intermission

3:10 A Graduate Program in Analytical Pharmaceutical Chemistry - L. F. Worrell, University of Michigan

3:40 Discussion

Saturday Morning, July 12

Tom D. Rowe, presiding

9:00 How Developments in Radioactivity Will Affect the Teaching of Courses in Pharmaceutical Chemistry - J. E. Christian, Purdue University

9:40 Discussion

9:50 Applications of Radioactive Tracer Techniques - D. L. Tabern, Abbott Laboratories

10:30 Discussion

10:45 Miscellaneous Remarks from the Floor

11:45 Adjournment

REGISTRANTS AND PARTICIPANTS

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